UNIVERSIDADE DA BEIRA INTERIOR
Ciências da Saúde

Use of information systems as tools to improve and measure leadership skills acquisition through medical simulation

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Dissertação para obtenção do Grau de Mestre em
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À minha Família.

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Resumo alargado

Contexto e objetivos

Num contexto de crescimento nos gastos com a saúde, acompanhado por uma pressão para redução desses mesmos custos, espera-se hoje dos médicos que sejam lideres em ambiente clínico e não clínico, com diferentes graus de responsabilidade. Contudo, a maior parte dos *curricula* médicos não inclui o ensino formal da Liderança e Gestão em Saúde. Por outro lado, estes *curricula* pré-graduados incluem cada vez mais a simulação biomédica enquanto método de ensino seguro e viável. Estes momentos representam muitas vezes a primeira oportunidade para os estudantes de atuarem enquanto equipa, gerindo uma situação de crise, durante a qual as competências de liderança são cruciais. No entanto, a maior parte das simulações não usa um sistema de registos clínicos eletrónicos que seja auxiliar nestes cenários. Assim, pretende-se através deste estudo demonstrar como é que a Liderança e Gestão em Saúde pode ser ensinada recorrendo à simulação e provar a possibilidade de introduzir um sistema de informação para gerir este processo. Ao fazê-lo, será possível sugerir um modelo de sistema de informação integrado para o ensino desta área de ensino.

Materiais e métodos

Foi utilizada uma metodologia mista, tendo sido combinadas duas experiências de investigação. Estas tiveram lugar no Laboratório de Competências da Faculdade de Ciências da Saúde da Universidade da Beira Interior, em Portugal. Em primeiro lugar, o autor concebeu e desenvolveu uma ferramenta para simular um software de registos clínicos eletrónicos. Depois, utilizando um modelo de triangulação, foi desenhada uma investigação no contexto do modulo de Liderança e Gestão em Saúde desta faculdade. Diversas sessões de simulação foram levadas a cabo, com o propósito de treinar as competências de liderança e trabalho em equipa. Foi recolhida e integrada informação de diversas fontes, nomeadamente de dois questionários, informação quantitativa do sistema de registos clínicos simulado, bem como de avaliação qualitativa dos vídeos gravados das sessões

Resultados

Foram avaliadas 16 equipas, num total de 85 estudantes (com idades compreendidas entre os 21 e os 36 anos, média de idades de 23,4, desvio padrão de 2,21). Uma componente importante da informação utilizada neste estudo foi obtida pelo sistema de registos clínicos simulado, sem o qual não teria sido possível recolher estes dados em qualidade e quantidade.

<u>Em termos de métricas de eficiência</u>, as equipas levaram entre 0 a 8 minutos para interagirem pela primeira vez com o sistema, entre 7 a 22 minutos para estabelecer um

diagnóstico correto para o paciente simulado e entre 9 e 27 minutos para executar o procedimento terapêutico de correção. Houve dois grupos que não estabeleceram o diagnóstico correto e consequentemente não efetuaram a terapêutica adequada. Em média, cada equipa fez quarto requisições de métodos complementares de diagnóstico, registou 2,44 entradas de história clínica e listou no sistema 74,3% dos procedimentos efetuados ao paciente. As equipas gastaram uma média de € 55,01 em métodos complementares de diagnóstico, quando traduzido em custo real.

<u>Considerando a autoavaliação de competências de liderança e gestão em equipa</u>, os grupos obtiveram uma classificação média global entre 2,83 e 4,28, de uma escala de Likert de 5 graus.

<u>Numa avaliação externa global às competências de liderança dos grupos</u>, obteve-se uma média de 3,43 e 3,33, respetivamente, recorrendo à mesma escala usada pelos estudantes e aplicando uma escalada adicional desenvolvida para o observador externo. 7 grupos foram classificados por este observador como tendo um estilo de liderança vertical, 4 foram classificados como alternantes, 3 com liderança partilhada e 2 como caóticos.

Do total de 85 estudantes, 35 preencheram um inquérito dois meses após a simulação. Todos os 35 estudantes (100% das respostas) sentiram que a simulação foi útil em termos de aquisição de competências de liderança e gestão. 88,6% estão interessados em ver as suas gravações de vídeo e 82,9% gostariam de ter este tipo de sessões de forma regular e frequente.

Discussão/conclusões

Foi possível estabelecer uma associação entre as métricas de tempo/eficiência com os estilos de liderança presentes em cada grupo. Equipas categorizadas como caóticas não chegaram a um diagnóstico final nem foram capazes de efetuar o procedimento terapêutico adequado. O maior número de interações com o sistema de registos, algumas delas repetidas, poderão suportar a atribuição destas categorias às equipas.

Este número de interações, num contexto real, poderia ter sido traduzido em custos superiores, quando comparado com outros estilos de liderança que não o caótico.

Numa realidade de responsabilização dos profissionais de saúde em funções de liderança, pareado com um crescente desenvolvimento tecnológico, bem como com uma utilização global da simulação enquanto ferramenta de ensino, o ensino da liderança recorrendo à simulação torna-se emergente e necessário.

Liderança e trabalho de equipa não se adquirem espontaneamente. Estes devem ser aprendidos e treinados, sendo a simulação uma ferramenta crucial para tal. A prática está associada a melhores e mais rápidas decisões, dado que as equipas passam a reconhecer mais cedo os eventos críticos e iniciam ações em resposta a estes. De facto, os estudantes indicam ter desenvolvido competências de liderança através destas simulações.

É possível introduzir um sistema de informação para gerir este processo, providenciando um enorme conjunto de dados, como os que foram utilizados neste estudo. Os sistemas de informação possibilitam a melhoria da qualidade dos dados e a capacidade para os analisar, extraindo métricas e análises relevantes, que não seriam obtidas de outra forma.

Apesar da amostra pequena deste estudo, foram encontradas diferenças relativamente à autoavaliação e heteroavaliação de grupos caóticos, que atribuíram classificações superiores a si próprios, quando comparados com a heteroavaliação efetuada por observador externo. Como sugerido por Rudy et. Al (2001) e Bryan et al. (2005), está demonstrado que estudantes com boas capacidades de liderança tendem a ser mais autocríticos na altura de se autoavaliarem.

A aprendizagem da liderança deve começar cedo, em ambiente universitário, e deve assentar em programas curriculares bem estruturados. Com esta estratégia, será possível enriquecer os estudantes com as competências necessárias para se tornarem os médicos do futuro, a cargo de múltiplas tarefas de gestão — clínicas ou não clínicas — ultrapassando os desafios colocados por uma saúde globalizada.

Este estudo demonstra a necessidade urgente de criar sistemas de informação integrados para monitorizar tais atividades de ensino, em tempo real, com potentes ferramentas de análise. Tal poderá permitir estudos retrospetivos e prospetivos, baseados em resultados clínicos ou outros, de médio e longo termos

Palavras-chave

Simulação biomédica, liderança, trabalho de equipa, registos clínicos eletrónicos, sistemas de informação, software.

Abstract

Background & Aims

In a context of health care rising demands, paired with a pressure to reduce costs, doctors are now expected to be leaders in clinical and non-clinical settings, with different levels of responsibility. However, the majority of medical curricula do not include formal training in management and leadership. Undergraduate medical curricula are integrating advanced clinical simulation as a safe and reliable learning method. It usually represents the first opportunity for students to act as a team managing a critical situation, during which leadership skills are crucial. Most of simulations do not use electronic health records system (EHR), thus not providing training in this important field. This study aims to demonstrate how an information system can assist medical simulations, both as learning and assessment tools, in terms of leadership skills acquisition. Thus, it is intended to show how can leadership and management be taught using simulation and prove if it's possible to introduce an information system to manage this process. By doing so, it might be possible to suggest a model of an integrated information system for teaching management and leadership.

Materials & Methods

A mixed methodology was used where two main research initiatives were combined. These took place in the Clinical Skills Lab of the Faculty of Health Sciences (University of Beira Interior), in Portugal. First, the author designed and developed a tool to simulate an electronic health records system, in tight collaboration with the Clinical Skills Lab. Then, using a triangulation model, an experiment was designed in the context of the Leadership and Management subject. Several simulation-based classes took place, with the purpose of training medical students in leadership. Data was collected and integrated with two survey data sets, quantitative information extracted from the EHR simulated system, as well as other qualitative data obtained or assessed by the author with the help of a video recording system.

Results

There were 16 teams/groups assessed, in a total of 85 students (aged between 21 and 36 years, average age of 23.4, standard deviation of 2.21. An important part of the data used for this study was obtained from the simulated EHR system, without whom it would not be possible to gather this study results.

<u>On efficiency metrics</u>, teams took between 0 and 8 minutes to make the first interaction with the simulated EHR, took between 7 and 22 minutes to establish the correct diagnosis and took between 9 and 27 minutes to execute the desired therapeutically procedure. There were 2

groups who didn't establish the correct diagnosis and consequently didn't performed the desired clinical attitudes and additional plus two groups that also didn't made the corrective therapeutic procedure. In average, each team made four complementary diagnostic test requisitions, registered 2,44 clinical history entries and listed in the system 74,3% of the executed procedures. Teams spent in average € 55,01, stated as real costs, in diagnostic tests.

Considering leadership and teamwork competencies self-assessment, groups obtained an average global rate between 2,83 and 4,28, out of a Likert scale of 5 degrees.

In a global external assessment on leadership skills, a total average of 3,43 e 3,33 was obtained, respectively, in a scale parallel to the one used in the self-assessment and in an additional questionnaire applied only during external analysis. 7 groups were categorized as having a direct leadership style, 4 as alternate, 3 as shared and 2 as chaotic.

From the 85 students, 35 filled a two month post simulation survey. All the 35 students (100% of the responses) feel this simulation was useful in terms of leadership skills acquisition. 88,6% are interested in having access to their own session's video recordings and 82,9% showed interest in having these sessions frequently.

Discussion/conclusion

It was possible to establish an association with time-related efficiency metrics with the leadership style present in each group. Groups categorized as chaotic did not reach a final diagnosis neither treat the simulated patient at their responsibility. The higher number of system interactions, sometimes repeated, can support the attribution of this categories to the groups.

These number of interactions, in a real situation, could have brought higher costs to the team when compared with other teams categorized with the remaining three leadership styles.

In a growing context of higher responsibility in healthcare worker's leadership, as with a crescent technological development and also with a broader use of simulation as a learning methodology, simulation based leadership learning becomes mandatory.

Teamwork and leadership does not occur spontaneously. It has to be learned and rehearsed and simulation is an excellent tool for teaching, rehearsing and analyzing team performance. Training is associated with timelier decision making as teams recognize critical events earlier and initiated interventions in a time critical manner. In fact, students claim to have learned by these simulation sessions.

It is possible to introduce an information system to manage this process, providing such amount of useful data used in this study. Information systems give us the ability to improve quality of data and capacity to work on that data, extracting useful metrics and analysis.

Despite the small sample of this study, differences were found regarding self-assessment and external assessment for chaotic groups, who rated themselves higher than the external observer did. Previously published results by Rudy et al. (2001) and Bryan et al. (2005) demonstrated that student leaders consistently scored themselves lower than their peers on many aspects of leadership, including altruism, compassion, integrity, accountability, commitment to excellence, and self-reflection.

Leadership learning must start early on, in the context of higher education, and it must settle in well-structured curricula. With this strategy it will be possible to provide students with the necessary skills to become the doctors of tomorrow, in charge of multiple management activities, being clinical or non-clinical, and exceeding the challenges posed by globalized healthcare.

This study showed the urgent necessity for the creation of systems that analyze training activities, around the clock and with powerful analytics engines. Such could allow prospective and retrospective studies based on clinical outcomes on a medium and long term.

Keywords

Medical simulation, leadership, teamwork, electronic health records, information systems, software

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Acronyms list

UBI	University of Beira Interior
LaC	Laboratório de Competências (Clinical Skills Lab)
OECD	Organization for Economic Co-operation and Development
GDP	Gross domestic product
EHR	Electronic health records
simEHR	Simulated electronic health records system
LLS	Leadership Learning System
EKG	Electrocardiogram
IT	Information technology

1. Introduction

In several countries, policy makers have a keen interest to understand population's health status, and to know how well their health systems are able to deliver good outcomes, the Organization for Economic Co-operation and Development (OECD) countries had organized themselves to monitor this annually[1]. People are living longer than ever before, with life expectancy now exceeding 80 years on average, a result of improvements in living conditions, educational support, but also, of the advances in healthcare processes. In most countries, universal health coverage provides financial protection against the cost of illness and promotes access to care for the whole population. The quality of care has also improved, as noted by the decline of the mortality rate from ischemic heart disease or cerebrovascular disease, and the earlier detection and effective treatments for serious diseases such as diabetes and cancer. This growth has come at a cost, however, with health spending now on averaging 9%-10% of the Gross Domestic Product (GDP) in OECD countries, and exceeding 10% in many countries. Growing health spending is not a problem if the benefits clearly exceed the costs, but there is broad evidence of inequities and inefficiencies in health systems which need fixture. There is also a impending need to achieve a proper balance between spending on disease prevention and treatment.

Healthcare expenditure in relation to the spending on all the other goods and services in the economy can be a function of both fluctuations in the rate of health spending itself as well as growth in the economy. The 2000s were characterized by a period of health spending growth above that of the overall economy so that health expenditure as a share of GDP rose sharply in many OECD countries. However, the economic *sub-prime* crisis that took place in 2008 resulted in an initial rise followed by a reduction in the health spending to GDP ratio across many OECD countries. Health spending accounted for 8.9% of GDP on average across OECD countries in 2013, unchanged from 2012 and up marginally from 8.8% in 2011. As an example, in 2013 the United States spent 16.4% of GDP on health. Portugal, despite being above the OECD average — spending 9.1% of its GDP in health care in 2013 — had an average of 3%/year reduction on its per capita health expenditure between 2009-13.

Yet even as demand rises and the economy flourishes, the pressure to reduce costs and demonstrate value is intensifying. While healthcare systems vary in their structure and available resources, it is widely recognized that medical doctors play a key role in the adaptation and performance of these systems (Waring J, et al. 2009). Physicians have a unique and decisive influence on the utilization of healthcare resources by prescribing

[1] http://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2015_health_glance-2015-en

treatments and drugs. They can play various formal and informal roles that help creating a rich environment for improved practices and ultimately increase patient safety and the performance of healthcare organizations (Bohmer RMJ, 2011 and Baker GR, et al. 2011)

Leadership and engagement of other professionals are crucial for crisis management and health system improvement as a whole. Leadership skills acquisition, contrary to what many believe does not come from daily practice context alone nor spontaneously. Like many skills it can come in different basal levels in different people but it surely requires on specific focus and effort for improvement, and particularly if it is to be start from early years in the medical training process.

The Faculty of Health Sciences (University of Beira Interior, Covilhã, Portugal), founded in the very beginning of this millennium, provides, through its medical curriculum, pioneer subjects and teaching methods in its daily activity.

Supported by a state-of-art Clinical Skills Lab (LaC)[2] students train several attitudes and procedures, in a fully implemented structured and transversal program, developing their professional and clinical skills.

Aware of the importance of leadership training starting at undergraduate education, this Faculty is the first and unique medical school in Portugal having a mandatory subject on leadership and management skills. This subject was introduced ten years ago and is integrated in the 5th year of the medical curriculum. Since its creation was aimed that simulation could be part of this subject's teaching methods, as a way to achieve higher levels of skills acquisition. In 2016, with the actual development of the Clinical Skills Lab's human and technical resources, the perfect environment was created for teaching leadership through medical simulation.

However, using simulation for the teaching of leadership skills to medical students, particularly college entry as it is the most common case in Portugal, is a subject that has not been addressed. Moreover, the role that simulated health information system records may have in this process was never studied, to the author's knowledge.

The aim of this study is to demonstrate how an information system can assist medical simulations, both as learning and assessment tools, in terms of leadership skills acquisition.

In order to attain to its aim, this study focuses on addressing four research questions:

- Is it possible to teach leadership and management with added value using simulation?

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[2] https://www.ubi.pt/en/page/LaC

- Is it possible to introduce an information system to manage this process?
- Assuming an established role for this information system support, is there any difference between self-perception and external observation of leadership skills acquisition?
- Is it possible to suggest a model of an integrated information system for teaching management and leadership?

1. Theoretical review

Literature review was performed in order to address four main research fields associated with this study research questions, mainly for research published during last 2 years, as shown on table 1.

Table 1 – List of some references consulted.

Research field	Summary	References	Used methodology
Simulation in medical education	The importance of having general guidelines and framework when developing programs using simulation as a teaching method.	Motola, I., et al (2013)	Review
	Learner-oriented simulations design.	Pasquale, S. J. (2015).	Review
	Effects of medical simulation on undergraduate students	Cortegiani, A. et al (2015)	Research study
	The importance of the simulation context, including room setting, interactions with the facilitator, etc.	Schaumberg, A. (2015).	Review
Information systems in medical education	The importance of providing training on EHR use at the medical school.	Matson et al. (2014)	Review
		Jansen, D. A. (2014)	Research study
	Report on a EHR based simulation curriculum.	Milano, C. (2014)	Case report
	Clinical skills Labs as EHR usability assessment environments.	Landman, A. B. (2014)	Case report
	EHR training and its relationship with patient safety improvements.	Stephenson, L. S. et al. (2014)	Research study
Teamwork skills education with simulation	The impact of multidisciplinary team simulation training on team performance and efficiency of patient care	Murphy, M. et al. (2015)	Review
	Students perceptions on teamwork skills acquisition through simulation	Sigalet, E et al. (2014)	Research study
	Teamwork skills and shared mental models in simulation.	Westli, H. K., et al. (2010)	Research study
	The importance of non-technical skills in simulation	Briggs, A., et al. (2015)	Research study
Leadership skills education with simulation	Video analysis of Intra- and Interprofessional Leadership Behaviors in clinical context.	Sadideen, H. et al. (2016)	Research study
	The importance of providing leadership and management education from the beginning of medical training.	Martins, H. M. G. (2010).	Review
	Considerations on leadership curriculum design for medical students.	Jorge, M. L. et al (2014)	Descriptive study
	Training leadership skills based on medical education	Kiesewetter, J., (2013)	Review

1.1. Simulation in medical education

A series of recent events has led to an increase use of clinical simulation in healthcare education. These include a higher focus on patient safety, based on a new training model not founded solely on knowledge acquisition, an ambition for standardized educational opportunities that are easily available, and a demand to practice skills in a monitored environment. In addition, validity in using simulation for healthcare education is increasingly reported in several articles, proving its benefits (Issenberg et al. 2005; McGaghie et al. 2010a).

“Simulation is a ‘hands-on’ (experiential learning) educational modality, acknowledged by adult learning theories to be more effective” (Ziv A. 2009) than learning that is not experiential in nature. It represents an opportunity for the learner to become engaged in the learning. In simulation, trainees learn with each other, with the educator and with the content presented in a specific environment.

Experiential learning stimulates students' critical thinking, problem-solving, and decision-making skills, all being goals of teaching using simulation. It “involves reflective thought, and influences subsequent actions and personal development” (Dunn WF, 2004). In experiential learning, trainees build knowledge by means of their interactions and experiences. Lave points out that “knowledge needs to be presented in settings and situations that would normally involve that knowledge” (Lave J, 2014). This process assumes that experiential learning builds knowledge in a more effective way, when compared with didactic presentations or online content distribution alone. Simulation improves the acquisition and retention of new knowledge compared with traditional methods. There is consensus in that “simulation offers a conducive environment for focused reflection and critical thought” (Huang GC, 2007). Harden et al. (2009) reminds us that “educators are becoming more aware of the need to develop forms of learning that are rooted in the learner's practical experience and in the job they are to undertake as a professional on completion of training.” Further, “learning takes place through the active behavior of the learner; it is what he does that he learns, not what the educator does” (Tyler R, 1949). Thus, the development of critical reflection skills, crucial in the debriefing process, is fundamental to effectiveness in healthcare.

It is important for learners to be engaged in activities that stimulate them to apply the knowledge they are trying to learn so they have the ability to apply it in differing situations. Application of knowledge is an essential feature of simulation and the learner's ability to apply the knowledge in various situations is crucial in clinical practice. Experiential learning offers the learner the opportunity to build knowledge and skills that are vital to their clinical practice. However, learning to apply previously acquired knowledge and skills to new situations requires practice and feedback. As noted in Kolb's cycle of experiential learning, the learner progresses through a cycle consisting of four related phases: concrete experience (an event), reflective observation (what happened), abstract conceptualization (what was learned and future implications), and active experimentation (what will be done differently). The learner's previous experiences have a direct impact to future learning, thus reflecting the importance of the four phases of the experiential learning process, in particular the aspects of what happened, what was learned, and future implications. As learners increasingly internalize this process of reflection on action, which takes place in simulation debriefings, it is expected that it will be supplemented by “reflection in action”, which occurs immediately, while the learning event is occurring (Kaufman DM, 2003).

1.2. Information systems in medical education

It has been increasingly demonstrated that EHR use improves the quality, efficiency, and cost of patient care. (Chaudhry B, et al. 2006; Buntin MB, et al. 2011);

To fully prepare medical school graduates to assume roles of increasing responsibility and leadership in modern health care systems requires developing their competence in patient-centered EHR use. However, most medical trainees receive little directed and uniform education in optimal use of EHRs (Hammoud MM, et al. 2012). Further, because of concerns about liability, billing, and patient safety, medical students’ access to EHRs is often limited, making them unable to document encounters, register past medical history, or enter create treatment/investigation orders (Mintz M. 2009).

Thus, although academic health centers are most of the time at the forefront of new technologies implementation - including electronic health records (EHR) – and often software and clinical simulation equipment, there is often a pitfall of functional and logical bridges between these two fields regarding medical learning (Jha AK, et al. 2009).

This lack of access and practices of EHR-based education prevents students from learning to use EHRs. Rather than being given opportunities to experience in simulated settings the mistakes and frustrations inherent in using EHRs, students often embark on a haphazard and variable learning curve in patient care settings, where their EHR education is directed with differing skill levels. Given this model, few students are likely to graduate feeling fully proficient or comfortable with their ability to use EHRs (Christina E, et al. 2014).

In fact, the use of EHR, at least in real clinical environment, is proven to be an important source of data, allowing for several metrics’ analysis and with an increasing potential to improve processes in several fields, from leadership to efficiency (Weiner J, et. al 2012)

1.3. Teamwork skills education with simulation

Teams are now expected to share a common goal, and to synchronize individual skills in interdependent collaboration in order to provide safe and efficient patient care (Murphy, M. et al. 2015). Although team members are sufficiently trained individually, teamwork skills have traditionally been less emphasized in medical training (Sexton JB, et. al 2000). The knowledge that fatal errors due to 'human factors' can occur in 70-80% of medical mishaps has led to growing interest in medical teams' cognitive and interpersonal skills, such as leadership and communication, which are referred to as 'non-technical skills'. Such ability has shown to have a critical role in maintaining patient safety (Fletcher G. 2000).

Teamwork is a key factor to patient safety. Healthcare is a multidisciplinary task where interaction of individuals from diverse backgrounds (expertise, training, experience, and culture) can affect patient care. These teams could be functioning in an environment characterized by high stress, high-stakes outcomes, and time pressures. Likewise, patient safety is directly impacted by teamwork. (Motola, I. et al 2013). The Joint Commission reports indicate miscommunication as the root cause of nearly 70% of sentinel events. Furthermore, a review linking teamwork and patient outcomes found empirical support for the relationship between teamwork behaviors and clinical patient outcomes.

Teamwork is a key factor to patient safety. Healthcare involves multidisciplinary work where interaction of individuals from diverse backgrounds (expertise, training, experience, and culture) have been show to affect patient care. These teams often operate in an environment characterized by high stress, high-stakes outcomes, and time pressures. Likewise, patient safety is directly impacted by teamwork. (Motola, I. et al 2013). The Joint Commission reports indicate miscommunication as the root cause of nearly 70% of sentinel events. Furthermore, a review linking teamwork and patient outcomes found empirical support for the relationship between teamwork behaviors and clinical patient outcomes. Salas and colleagues point out that:

> *''training also provides opportunities to practice (when used with simulation) both task- and team-related skills in a 'consequence-free' environment, where errors truly are opportunities for learning and providers receive feedback that is constructive, focused on improvement, and non-judgmental'' (Salas et al. 2008)*

Team training works in carefully designed curricula which allow opportunities for the deliberate practice of teamwork skills in a simulation-based medical environment (McGaghie et al. 2010a). A growing body of literature indicates the impact of teamwork on clinical outcomes in several diverse clinical settings, such as ambulatory care (Campbell et al. 2001), nursing homes (Rantz et al. 2004), community-based care (Mukamel et al. 2006), emergency departments (Morey et al. 2002), intensive care units (Young et al. 1998; Wheelan et al. 2003; Dubose et al. 2008), operating rooms (Undre et al. 2006; Lingard et al. 2008), labor and delivery units (Thomas et al. 2006;Mooney & Neily 2007) and inpatient wards (Curley et al. 1998; Strasser et al. 2008). Despite the growing evidence and involvement from various healthcare disciplines, team training programs have struggled to achieve desired outcomes. Training success is highly dependent not only on curricula and instructional strategies, but on several more complex organizational variables such as leadership support, resource availability, training environment, and readiness for change (Salas et al. 2009).

Teamwork does not occur spontaneously. It has to be learned and rehearsed and simulation is a valuable tool for teaching, studying and analyzing multidisciplinary team performance.

1.4. Leadership skills education through simulation

Key leadership attributes are well defined in the literature and encompass multiple virtues, which include technical competence, professionalism, motivation, innovation, teamwork, effective communication, emotional competence, and teaching; they can be developed through observation, experience, and education. (Patel VM, et al. 2010). Leadership is particularly important in highly complex health care contexts involving a number of staff, some from the same specialty (intraprofessional), and others from different specialties (interprofessional). Recently, interprofessional teamwork has become an important aspect of work in healthcare (Reeves S. et al. 2012). Maximizing patient safety and reducing medical errors depends not only on technical expertise but also on how decisions are made and how relevant information is communicated and tasks are coordinated.

Despite the importance of training of leadership skills in medical curricula for professional collaboration as well as patient care, it is under-represented in several known catalogues of learning objectives (Kiesewetter, J. et al. 2013)

There is a correspondingly low number of findings as to how the development of leadership skills can be integrated into medical training and what effects the development measures can aim to attain. It is well established that simulation can play a powerful role in clinical training (Sadideen H. et al. 2012). Educational theory highlights the importance of contextualized simulation for effective learning (Kneebone R. 2010). Such elements are more complex and much harder to define than technical skills. Within the appropriate context and design, simulation may therefore provide a unique opportunity to help trainees/residents develop adequate leadership skills. Simulation-based team training and debriefing is an evolving educational strategy that encourages work-based learning, collaboration, and teamwork (Severson MA. et al. 2014).

This training can be useful at the different stages of a physician's career and are likely to be taught best in a progressive manner, in a spiral educational structure, which can be split into four main stages: A) medical school; B) residency; C) medium-level responsibilities (e.g., leadership of a unit); and D) senior levels (e.g., leadership of a department). Each stage has inherent challenges and opportunities, which will make education in these areas invaluable (Martins H. 2010).

Yet from their very first day at work, physicians are expected to take on the role of a leader, to bear responsibility and to make important medical decisions facing a heterogeneous environment. As they do this, taking an active leadership role and implementing managerial behavior contribute to more effective teamwork and good patient care (McGaghie WC, et al. 2009).

The need for medical students and young doctors to be introduced to their leadership roles in the context of their training is well accepted. The concept of leadership here comprises exercising conscious, goal-oriented social influence on people for the purpose of performing shared tasks in pursuit of common objectives, and focuses on leading subordinates, colleagues and teams (Bruch H. et al. 2006). The active adoption of a leadership role and the associated implementation of leadership skills include, as stated by Schmidt-Huber, Frey, Peus & Weisweiler, motivating team members, building up on trust, organizing work activities and delegating tasks and responsibility, being able to communicate effectively while managing change and conflicts. The good leader should ensure good quality work, in an efficient way.

2. Methods

2.1. Type of study and methods

There are several factors impacting medical education processes, including those relating to the school, faculty, other students, specific project, dimensions of assessment and cultural and social context. Therefore, using a single research perspective may be reductionist for studying medical education. While knowing what works is important, an appreciation of why it works, when it works, and for whom it works is needed to deepen our understanding of learning and teaching in medicine (Cook, Bordage, & Schmidt 2008).

Different methods can be combined to the development and extension of the research scope and depth of analysis. Mixed methods research is ideal for the improvement of teaching and learning in the medical profession. The comprehensive and heterogeneous approach supports validity, answers questions in a rich and meaningful way, provides new insights and, potentially, raises new questions on the nature of learning and instruction. This approach offers the researcher an opportunity to go in a new direction, to experiment, and to create meanings that could not be possible to achieve by using a single method. (Lavelle, et. al 2013)

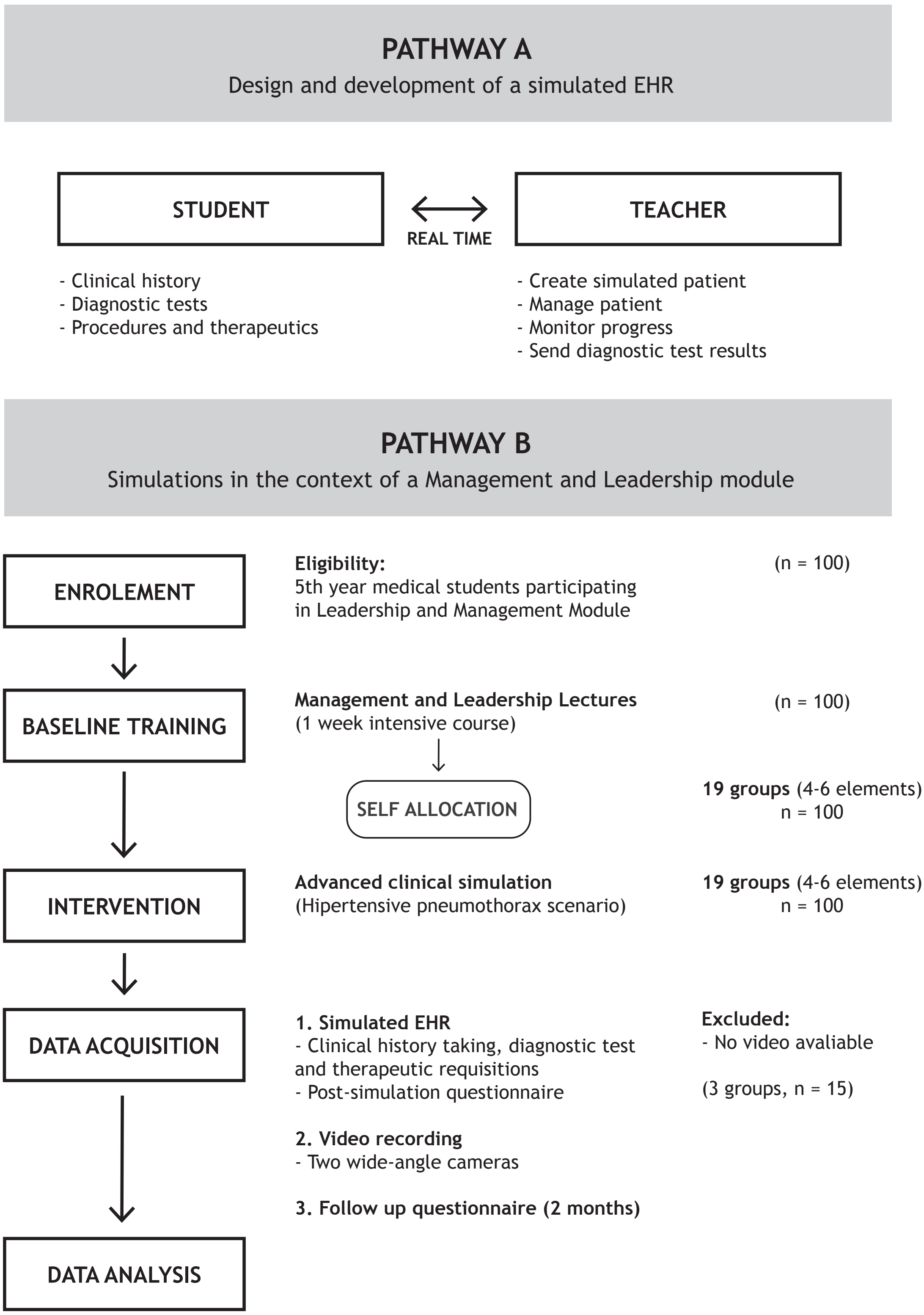
Leech & Onwuegbuzie (2009) provide a simple definition of mixed methods research: "collecting, analyzing, and interpreting both qualitative and quantitative data in a single study, or series of studies that investigate the same underlying paradigm".

2.2. Study design

A mixed methodology was used where two main research initiatives were combined. These took place in the Clinical Skills Lab of the Faculty of Health Sciences (University of Beira Interior), in Portugal.

First, the author designed and developed a tool to simulate an electronic health records system, in tight collaboration with the Clinical Skills Lab. Then, using a triangulation model, an experiment was designed in the context of the Leadership and Management subject. Several simulation-based classes took place, with the purpose of training medical students in leadership.

Data was collected and integrated, two survey data sets, quantitative information extracted from the EHR simulated system, as well as other qualitative data obtained or assessed by the author with the help of a video recording system.



Graphic 1 – Study methodology summary

Pathway A – Design and development of a simulated EHR tool

Medical simulations lack high fidelity in several aspects. One of the areas that can be better addressed is the integration of information systems, specifically concerning the use of electronic health records. No commercial software was found to be available for clinical management of advanced medical simulation scenarios.

Software design process

A software application was designed and developed. This is a two-way interface system, allowing for real-time interaction between trainees in the simulated emergency room and the educators, functionality was a key concern. This software was created to be used as support tool in the context of a simulated emergency room with an advanced mannequin simulator.

A series of most frequent diagnostic tests that could be useful in a simulation context, based on the preprogramed scenarios, as well as, common clinical practice, was collected to inform software design. Biochemical, analytical, imaging and microbiology categories were covered, as well as general diagnostic tests such as electrocardiogram (EKG). Each diagnostic test had information about the commonly used units in typical Portuguese hospitals and reference values when applicable. In the back office of the application, these were additionally marked with the NHS cost.

Given the educational context and the turnover of clinical scenarios, it was assumed that the educator should be capable of creating standardized patients, based on their presenting diagnosis. For each presenting diagnosis, the educator is able to define a range of presenting age (10 years range), patient gender and to configure several diagnostic test results sets, one for each phase of the scenario, including image upload for imaging tests or EKG.

It is then possible to create one unique patient for each simulation session, with a randomized name based on defined gender, an age with 10% variability around the predefined value of the standardized patient created before, as well as diagnostic test results with some variability (5%). This variability is possible for diagnostic test results represented by numbers.

Every time a new patient is created from a predefined diagnosis, the queue of observation is updated, allowing students to select the desired patient and to start the simulation. This randomization is important to assure that students cannot easily recognize the scenario.

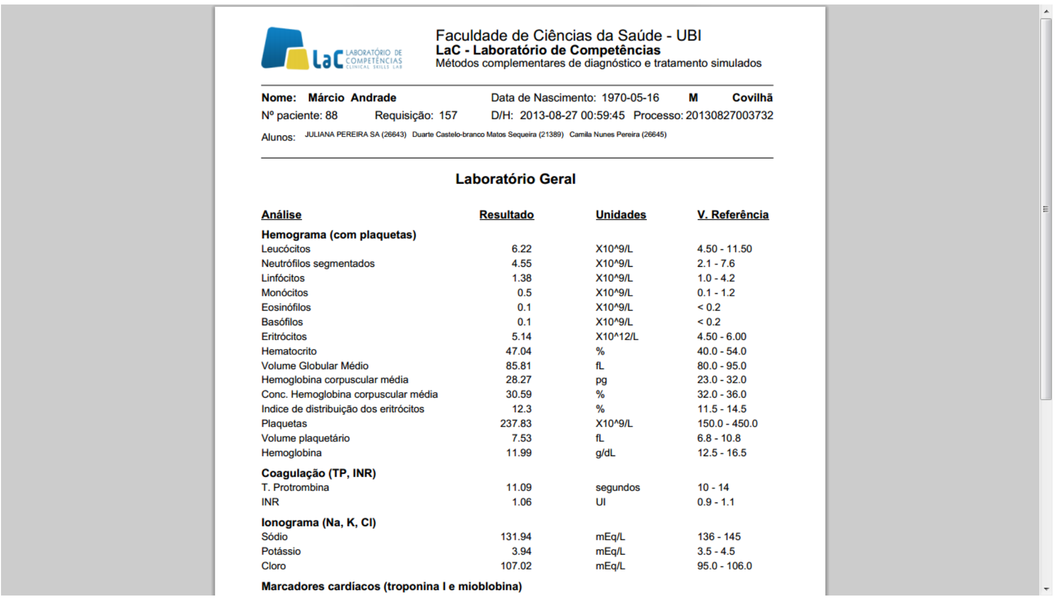
After selecting the desired patient, students have at their disposal a series of features, allowing for close interaction with the control room, as described in the following sections.

Students' interface features

In terms of students' interface, this system is a simplification of a regular electronic health system, allowing them to check patient entry notes, record clinical history and observation, log medical procedures and request diagnostic tests. Students are also able to insert the differential diagnosis that lead the course of actions.

Image 1 – Example of students' interface.

Every time a diagnostic test result is made available by the instructor in the control room, a sound is played in the students' interface. Although such would not be the case in standard EHRs in real world it is relevant in a context of a "compressed time simulation".



Faculdade de Ciências da Saúde - UBI
LaC - Laboratório de Competências
Métodos complementares de diagnóstico e tratamento simulados

Nome: Márcio Andrade Data de Nascimento: 1970-05-16 **M** **Covilhã**
Nº paciente: 88 Requisição: 157 D/H: 2013-08-27 00:59:45 Processo: 20130827003732
Alunos: JULIANA PEREIRA SA (26643) Duarte Castelo-branco Matos Sequeira (21389) Camila Nunes Pereira (26645)

Laboratório Geral

Análise	Resultado	Unidades	V. Referência
Hemograma (com plaquetas)			
Leucócitos	6.22	X10^9/L	4.50 - 11.50
Neutrófilos segmentados	4.55	X10^9/L	2.1 - 7.6
Linfócitos	1.38	X10^9/L	1.0 - 4.2
Monócitos	0.5	X10^9/L	0.1 - 1.2
Eosinófilos	0.1	X10^9/L	< 0.2
Basófilos	0.1	X10^9/L	< 0.2
Eritrócitos	5.14	X10^12/L	4.50 - 6.00
Hematocrito	47.04	%	40.0 - 54.0
Volume Globular Médio	85.81	fL	80.0 - 95.0
Hemoglobina corpuscular média	28.27	pg	23.0 - 32.0
Conc. Hemoglobina corpuscular média	30.59	%	32.0 - 36.0
Indice de distribuição dos eritrócitos	12.3	%	11.5 - 14.5
Plaquetas	237.83	X10^9/L	150.0 - 450.0
Volume plaquetário	7.53	fL	6.8 - 10.8
Hemoglobina	11.99	g/dL	12.5 - 16.5
Coagulação (TP, INR)			
T. Protrombina	11.09	segundos	10 - 14
INR	1.06	UI	0.9 - 1.1
Ionograma (Na, K, Cl)			
Sódio	131.94	mEq/L	136 - 145
Potássio	3.94	mEq/L	3.5 - 4.5
Cloro	107.02	mEq/L	95.0 - 106.0
Marcadores cardíacos (troponina I e mioblobina)			

Image 2 – Example of a diagnostic test result

Control room interface features

Educators have the ability to create predefined patients based on diagnosis and to generate patients from them. These patients are then made available for use in a simulation session, as described previously.

Image 3 - Example of the control room interface (for teacher)

Focus is put in the control room interface, designed for real-time checking of students' performance in terms of data entries and as a manner to reply with diagnostic tests results as they request them, allowing students to consult them in their interface. Educators also have the possibility to rate every action (data entry, diagnostic test requisition, etc.) as positive, negative or neutral and to send text alerts to the room.

Image 4 – Example of the control room interface (for teacher)

This tool allows for different metrics extraction, timeline visualization and graphics generation. Thus, it facilitating the debriefing process as the reports that are generated are an important source of data.

Used technology

This web-based software runs in a regular internet browser and was developed using PHP® as the server-side language, combined with HTML®, CSS® and JavaScript for the front-end interface design. All the information is stored in a MySQL® database. As a way to allow for high portability, this system is hosted by a small Raspberry Pi®, a single board computer with the size of a credit card, connected to the intranet of the Clinical Skills Lab.

Pathway B – Simulations in the context of a Management and Leadership module

This pathway was conducted in the Clinical Skills Lab of the Faculty of Health Sciences (University of Beira Interior), in Portugal, during February 2016, in the context of Management and Leadership module, a compulsory program for 5th year medical students as previously described. In the last step of the program, students were given freedom to group themselves in teams of 4-6 students (n=100 students) and were scheduled to participate in an advanced simulation.

All the teams were submitted to the same clinical case (although patient personal details varied) and were specifically asked not to share information with the other groups. Neither of the groups were aware of the simulated patient condition before having contact with it. Each clinical scenario started with a role-playing nurse urgently asking the team to assess and manage patient's condition. The simulated patient (iStan METI ® Simulator) represented a male individual aged between 67 and 73 presenting with an acute onset dyspnea losing consciousness within two minutes from the start. Students were expected to use an ABCDE approach, asking for needed diagnostic tests and performing clinical procedures. In all sessions, an actor performed as an nurse, collaborating with students during simulation. Sessions took 15-30 minutes each, with some outliers with more duration, caused by clinical condition worsening events. Those events were induced when there wasn't proper management of the presenting clinical condition, aiming to introduce leadership style transformations within the team.

Simulated scenarios were run in an advanced simulation room, equipped the same way as an emergency ward, including a crash cart, a vital signs monitor, a telephone (contact with consultants, labs, radiology) and visible Advanced Cardiac Life Support guidelines posted on the wall.

There was also a computer with the simulated electronic health records software, as described previously.

During the study, several action triggers were introduced in each scenario and improved to which the participants were exposed, such as the need to deal with the simulated patient family, the ought to wait for the diagnostic tests results or even the need to hold the line while dialing to other "hospital" departments, when asking for their collaboration.

In the end of the simulation, prior to debriefing moment, students were asked to fill out an individual survey addressing their perceptions about individual and group attitudes towards the session, regarding leadership and clinical reasoning skills (annex 1).

All the sessions were video recorded (METI Learning Space ®) in order to assess key points, action triggers and execution times. For the purpose of this study, timestamps from video and software data were synchronized. Videos were reviewed after all the sessions. In this process, attention was paid to key leadership behaviors.

Data inputs resulting from the use of the EHR simulated software was compared between groups. All the main actions performed during the scenario were valued in terms of costs, e.g., requested diagnostic tests and given therapies.

The video analysis was grounded-theory inspired to examine leadership behaviors in this dynamic context. The purpose of this is to analyze self-perceptions regarding their leadership and team performance and the assessment made by the author of this study.

For the purpose of this study, it was assumed that assessing the clinical outcome of each scenario shouldn't be the primary objective. Therefore, debriefing time was mainly dedicated to explore group's general feelings and their perceptions on leadership roles and styles.

Students were briefed about the available material and software prior to the beginning of simulation. Consent was given by all the participants to allow for use of several data inputs, namely: recorded video and software generated data.

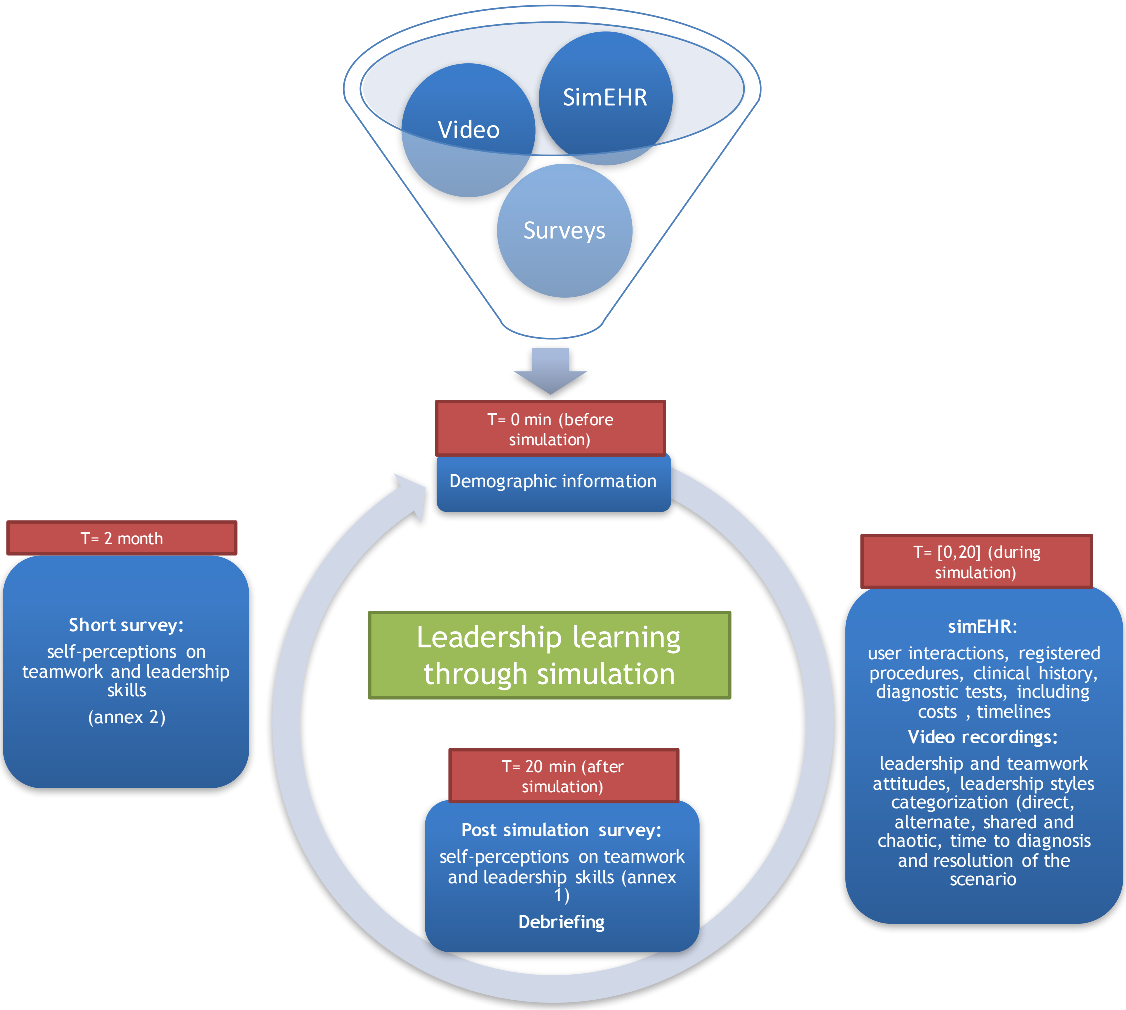
Two months after the simulation, students received a short individual survey in their email, containing three questions regarding their perception of leadership skills acquisition, willingness to have access to their own video recordings and desire of having regular simulations in the future.

2.3. Data analysis

Data was prepared and analyzed using descriptive statistics and analytics when adequate. Analysis was performed regarding pathway B with respect to the dimensions and instruments mentioned in table 2.

Table 2 – Description of analyzed data sources and its relationship with capture time and specific dimension.

Time	Analyzed data, per instrument	Dimension			
		Demographics	Teamwork and leadership	Performance and efficiency	Clinical outcome
Before simulation	• Age • Sex • Previous university frequency	✔			
During simulation	**simEHR**: • user interactions • registered procedures, clinical history, diagnostic tests, including costs • timelines **Video recordings:** • leadership and teamwork attitudes • leadership styles categorization (direct, alternate, shared and chaotic) • time to diagnosis and resolution of the scenario		✔	✔	✔
Immediately after simulation	**Post simulation survey:** • self-perceptions on teamwork and leadership skills (annex 1)		✔		
Two month later	**Short survey:** • self-perceptions on teamwork and leadership skills (annex 2)		✔		



Graphic 2 – Data analysis process summary

Data and graphics were analyzed and generated using Microsoft Office Excel 2016® and Google Spreadsheets®.

3. Results

3.1. Study population

As previously stated, 100 students grouped themselves in 19 teams, according to their preferences. From those 19, 3 teams were excluded from the study since there was a a technical problem with the video recording system, not allowing for video capture. Thus, 16 teams participated in this study with a total of 85 medical students attending the fifth year in the University of Beira Interior, aged 21 to 36 years (mean 23.4; standard deviation of 2.21).

Table 3 – Study population and its distribution per team.

Group	Number of Students	Average age	Age (standard Deviation)	Women (%)	Men (%)	Previous University frequency
A	5	22,60	1,95	60%	40%	20%
B	6	24,00	2,10	100%	0%	33%
C	5	22,60	0,89	60%	40%	0%
D	4	23,00	1,41	50%	50%	25%
E	5	23,80	1,30	100%	0%	80%
F	5	22,80	0,84	0%	100%	20%
G	7	22,29	0,49	57%	43%	29%
H	7	23,29	1,60	71%	29%	29%
I	7	23,86	1,77	86%	14%	57%
J	5	26,40	3,36	0%	100%	60%
K	5	22,80	1,10	60%	40%	20%
L	5	22,20	0,45	80%	20%	20%
M	5	22,60	0,55	40%	60%	40%
N	5	25,40	5,98	100%	0%	40%
O	5	23,00	2,35	40%	60%	40%
P	4	23,75	1,50	0%	100%	50%
Population average	*5,3*	*23,38*	*2.21*	*59%*	*41%*	*35%*

3.2. Metrics obtained through simulated EHR and video

In order to assess the group's performance and efficiency, metrics were extracted from the software running a simulated EHR and coupled with data from observation of recorded video.

Times

Decision-making, can take more or less time. In the context of team or collective decision-making this variability is often dependent on communication and leadership. Measuring time for relevant or critical decisions can serve as a proxy of efficiency in team decision-making and its leadership. Such values can be interpreted as a measurement of efficiency. A series of time periods were measured, these were:

a) time (in minutes) to the first interaction with the simulated EHR (to register clinical information, assign prescription or request complementary diagnostic tests),
b) time (in minutes) to requisition of the first complementary diagnostic test was obtain through the software, considering the clinical case being used, time to EKG and thoracic radiograph requisition were considered;
c) time (in minutes) to correct diagnosis - pneumothorax
d) time (in minutes) to execution of the desired therapeutic procedure – chest tube placement

In the specific cases where groups could not reach the final diagnostic or procedure, no time was considered. Table 4 presents teams' different times.

Table 4 – Measured times

Group	Time to first contact to simEHR (min)	Time to first diagnostic test order (min)	Time to EKG (min)	Time to chest x-ray (min)	Time to diagnosis (min)	Time to resolution (min)
A	2	5	-	-	-	-
B	2	2	2	2	9	-
C	2	6	8	-	11	-
D	8	8	-	8	11	13
E	2	2	2	4	16	27
F	3	3	3	6	13	17
G	2	8	-	9	9	18
H	0	2	11	6	17	25
I	1	1	1	7	9	9,5
J	0	3	-	3	13	15
K	3	3	3	20	22	25
L	3	4	8	5	-	-
M	4	4	4	5	7	9
N	6	6	6	15	15	15
O	2	5	5	6	14	16
P	2	4	11	14	18	23
Average	**2**	**4**	**4,5**	**6**	**13**	**16,5**

(Greener tones indicate better performance than the yellow average. Red indicates the opposite)

System interactions and compliance metrics

Several metrics were obtained concerning the number of input registrations performed by users:

- Number of diagnostic test requisition. This study refers to diagnostic test requisition as a requisition made in the simulated EHR software in one specific moment, containing one or more diagnostic tests, as in a real setting.
- Number of history entries, calculated by the number of notes added to the patient history.
- Number of registered differential diagnosis.
- Total number of registered procedures and its relation with the total amount of procedures identified by video observation.

These metrics were selected because they match core features of any EHR system. Therefore, the number of complementary diagnostic tests requisitions, the number of clinical input - such as clinical history and physical examination - and the number of differential diagnosis were logged and exported from the software.

Through the video analysis the number of executed procedures was obtained. In this context, any therapeutic intervention was considered as a procedure and any diagnostic procedure was excluded. The result was cross checked with the number of therapeutic interventions registered in the simulated EHR, to assess the accuracy between registered data and reality.

Table 5 - System interactions and compliance

Group	# Diagnostic test requisitions	# History entries	# Diferential diagnosis	#Registered procedures	# Total procedures	% registred procedures
A	3	5	0	2	3	67%
B	2	3	0	0	1	0%
C	2	3	1	7	7	100%
D	3	0	0	1	4	25%
E	6	3	3	3	7	43%
F	4	1	3	4	7	57%
G	2	4	3	0	5	0%
H	4	5	2	8	8	100%
I	4	0	1	10	10	100%
J	4	3	1	7	7	100%
K	5	0	0	1	6	17%
L	6	4	3	13	13	100%
M	3	0	0	0	4	0%
N	5	6	1	10	10	100%
O	7	2	2	7	10	70%
P	3	0	1	11	11	100%
AVG	3,94	2,44	1,31	5,25	7,06	61%

Costs with diagnostic tests

The following values were obtained, in euros, per group, calculated from exams ordered via application exams. All the requested diagnostic tests for each team were counted in this section.

Table 6 – Costs with diagnostic tests, per group

Group	*Spent money on diagnostic tests*
A	57,42 €
B	26,00 €
C	31,45 €
D	29,70 €
E	87,52 €
F	61,92 €
G	52,65 €
H	61,32 €
I	51,37 €
J	55,52 €
K	41,47 €
L	104,20 €
M	35,62 €
N	70,12 €
O	91,87 €
P	22,00 €
AVG	55,01 €

3.3. Leadership and teamwork: self-assessment (post-simulation survey)

Immediately after the simulation scenario, students were asked to fill a questionnaire (annex 1) to assess their perception of the group's leadership and teamwork actions during the scenario. All the eighty-five students completed the questionnaire, composed of five questions answered through a Likert scale from one to five.

Table 7 – Self-assessment of leadership and teamwork, per group, based on surveys for each team member

Group	Did you feel that there was a clear leadership of the team in all moments?	Did you feel that tasks were clearly assigned and distributed?	Did you feel all team members participated actively in case resolution?	Did you feel the team communicated effectively?	Did team members asked for group's opinions?	GROUP AVERAGE
A	2,4	3,2	3,8	3,6	4,4	3,48
B	2	2,17	3,67	2,5	3,83	2,83
C	3	2,8	3,4	3,6	4,2	3,4
D	2,25	2	3,25	3,75	4,5	3,15
E	3	2,6	4,2	3,4	4,6	3,56
F	3	2,8	4,4	3,6	4,4	3,64
G	3	2,43	3,71	3,14	4,43	3,34
H	2,86	3,29	4,43	3,57	4,43	3,71
I	3,57	4	4	3	3,43	3,6
J	2,2	2,8	3,8	2,8	3,4	3
K	2,8	2,6	4,2	3,6	4,4	3,52
L	2,8	2,8	4,6	4,2	4,6	3,8
M	2,4	3	4,2	2,6	4,2	3,28
N	2,4	2,4	3,2	2,8	4,4	3,04
O	4	4,2	4,4	4,2	4,6	4,28
P	2,5	4	4,75	4,5	4,75	4,1
Question average	2,76	2,94	4,00	3,43	4,29	**3,48**

(Greener tones indicate better performance than the yellow average. Red indicates the opposite)

3.4. Leadership and teamwork: external assessment (video analysis)

One analyst watched the recorded videos – total duration of six hours and eleven minutes – without having access to the students' self-assessment, neither to other metrics of this study during his assessment.

This process had three objectives:

I. Classify the groups with one predominant leadership style;
II. Assess the group's leadership and teamwork actions with the same self-assessment questionnaire students were asked to answer;
III. Assess the group's leadership and teamwork skills based on a different scale, in order to gather more data, according to Zaccaro et al, 2001.

I. Leadership style classification

Based on video observation, the observer categorized each group in one of the following leadership styles:

- Vertical/Direct leadership, with one identified leader of the team.
- Alternate leadership, a derivation of the direct leadership style, in which there is leadership rotation between two elements of the group.
- Shared leadership (laissez-faire), a leadership that is broadly distributed, such that people within a team and organization lead each other.
- Chaotic, in which there is no identified leaders and all the team acts by their own, without proper guidance or common agreement on tasks and plans.

7 groups were categorized as having a direct leadership style, 4 as alternate, 3 as shared and 2 as chaotic.

Table 8 – Leadership styles and group distribution.

Direct	Alternate	Shared	Chaotic
C	D	B	A
E	H	F	L
G	I	K	
M	J		
N			
O			
P			

To facilitate visual analysis of results, further tables of group results will display groups listed in clusters (direct, alternate, shared, chaotic) and with the same color code present in table 8.

II. Leadership and teamwork scale (same as students)

By watching video recordings of each session, the observer applied the same scale answered by the students in their self-assessment, rating the same questions for each group with a 1-5 Likert-scale.

Table 9 – Leadership and teamwork external assessment

Group	Predominant observed leadership style	Did you feel that there was a clear leadership of the team in all moments?	Did you feel that tasks were clearly assigned and distributed?	Did you feel all team members participated actively in case resolution?	Did you feel the team communicated effectively?	Did team members asked for group's opinions?	GROUP AVERAGE
C	Direct	4	4	3	5	4	4
E	Direct	3	3	4	3	4	3,4
G	Direct	3	1	4	3	4	3
M	Direct	4	3	4	3	4	3,6
N	Direct	3	4	4	4	4	3,8
O	Direct	5	4	5	5	4	4,6
P	Direct	2	4	4	3	3	3,2
D	Alternate	2	2	3	3	3	2,6
H	Alternate	3	3	4	4	4	3,6
I	Alternate	4	4	4	4	4	4
J	Alternate	2	3	4	3	4	3,2
B	Shared	3	3	3	4	4	3,4
F	Shared	2	3	5	5	5	4
K	Shared	3	2	4	3	4	3,2
A	Chaotic	1	2	4	2	3	2,4
L	Chaotic	2	2	4	3	3	2,8
QUESTION AVERAGE		**2,88**	**2,94**	**3,94**	**3,56**	**3,81**	**3,43**

(Greener tones indicate better performance than the yellow average. Red indicates the opposite)

III. Leadership and teamwork scale (specific for the observer)

This results from the application of a 1-5 likert-scale, based on video observation, according to Zaccaro et al, 2001, translated into three parameters each:

- Information search and structuring:
    - Data acquisition
    - Organization and structuring of data
    - Information feedback
- Information use in problem solving:
    - Identification of additional needs and restrictions
    - Planning and coordination
    - Communication
- Managing resources:
    - Assigning tasks to team members
    - Motivation
    - Monitoring

Table 10 – Leadership and teamwork external assessment (specific for observer)

Group	Predominant observed leadership style	Obtains information	Organizes information	Gives feedback	Makes assessment of needs	Plans and coordinates	Comunicates	Assigns tasks	Motivates	Monitors the situation	GROUP AVERAGE
C	Direct	4	5	5	4	5	4	4	1	1	3,67
E	Direct	4	3	4	4	4	4	3	4	3	3,67
G	Direct	3	3	2	3	3	3	1	1	1	2,22
M	Direct	4	4	4	4	4	4	4	3	4	3,89
N	Direct	4	5	5	4	4	4	4	4	5	4,33
O	Direct	5	5	5	5	4	5	5	4	5	4,78
P	Direct	4	5	4	4	2	2	4	2	4	3,44
D	Alternate	4	3	3	3	3	3	3	1	2	2,78
H	Alternate	4	4	4	4	4	4	3	2	4	3,67
I	Alternate	5	4	4	4	4	4	3	2	4	3,78
J	Alternate	4	4	4	4	4	3	3	1	3	3,33
B	Shared	3	2	4	3	2	4	1	1	1	2,33
F	Shared	4	4	3	4	3	5	4	1	3	3,44
K	Shared	3	2	4	3	3	4	4	2	4	3,22
A	Chaotic	4	3	2	4	3	4	1	1	1	2,56
L	Chaotic	2	2	2	2	3	3	2	1	3	2,22
QUESTION AVERAGE		3,81	3,63	3,69	3,69	3,44	3,75	3,06	1,94	3,00	3,33

(Greener tones indicate better performance than the yellow average. Red indicates the opposite)

3.5. Two month after simulation survey

Self-perception on leadership skills acquisition

An anonymous questionnaire was sent to the students' institutional e-mail address two months after the completion of the simulation scenario.

Firstly, students were asked to assess the utility of simulation as a means to leadership skills acquisition. Secondly, they were asked to express their interest in having more regular contact with simulation scenarios. Finally, students were asked whether they would like to review the video recordings of their sessions as well as the accompanying analysis.

From the 85 students, 35 filled the survey. All the 35 students (100% of the responses) feel this simulation was useful in terms of leadership skills acquisition. 88,6% are interested in having access to their own session's video recordings and 82,9% showed interest in having these sessions frequently.

4. Analysis and integration of results

Groups were categorized by leadership style observed by the video reporter, then each leadership style was evaluated in two main areas: leadership and teamwork; efficiency and performance.

4.1. Leadership and teamwork

Self-assessment

As it was described above, self-assessment of leadership and teamwork relied on the evaluation of the self-awareness of leadership, clear distribution and assignment of tasks, active participation of the entire team, effective communication and integration of team's opinions.

In the first question, only the direct leadership groups rated (2,90) above the average (2,79) in having a clear self-perception of leadership. Chaotic and shared groups rated the same 2.60 points.

As for task division and assignment, direct leadership groups rated themselves higher with an average of 3,06 points. On the other hand, shared leadership groups rated themselves the lowest, with an average of 2,52 points in this question. Global average was 2,95 points.

In active participation of the team's members, chaotic and shared leadership groups rated themselves above global average (4,00) with 4,20 and 4,09 points, respectively. Below average were direct and alternate leadership groups with 3,98 and 3,87 points.

In the self-assessment of communication, differences were more pronounced, chaotic groups participants rated themselves with an average of 3,90 points, the highest score, and shared leadership rated themselves with an average of 3,23 points, the lowest. The global average was 3,39 points.

Finally, regarding integration of group's opinions, chaotic groups rated themselves higher with 4,50 points and alternate leadership groups rated themselves the lowest with an average of 3,94 points. Global average was 4,26.

Table 11 – Leadership and teamwork self-assessment, per leadership style.

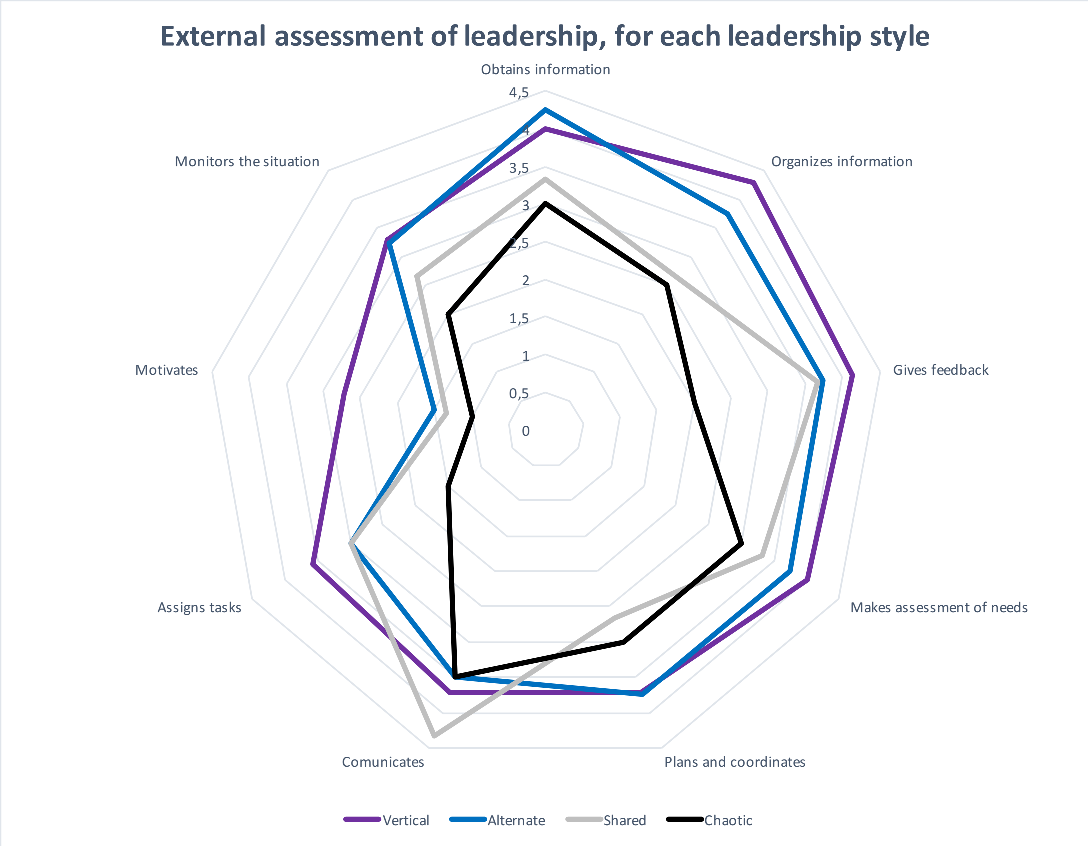
	Did you feel that there was a clear leadership of the team in all moments?	Did you feel that tasks were clearly assigned and distributed?	Did you feel all team members participated actively in case resolution?	Did you feel the team communicated effectively?	Did team members asked for group's opinions?
Direct	2,9	3,06	3,98	3,46	4,45
Alternate	2,72	3,02	3,87	3,28	3,94
Shared	2,6	2,52	4,09	3,23	4,21
Chaotic	2,6	3	4,2	3,9	4,5
ALL GROUPS AVERAGE	**2,79**	**2,95**	**4**	**3,39**	**4,26**

External assessment

The observer's average classification for each students' group and its leadership style show interesting patterns. Chaotic groups rate poorly in all the items except for communication. On the opposite side, the vertical groups rate best in almost all the items assessed by the observer.

Table 12 – Leadership and teamwork external assessment, per leadership style.

	Obtains information	Organizes information	Gives feedback	Makes assessment of needs	Plans and coordinates	Comunicates	Assigns tasks	Motivates	Monitors the situation	LEADERSHIP TYPE AVERAGE
Direct	4	4,29	4,14	4	3,71	3,71	3,57	2,71	3,29	3,71
Alternate	4,25	3,75	3,75	3,75	3,75	3,5	3	1,5	3,25	3,39
Shared	3,33	2,67	3,67	3,33	2,67	4,33	3	1,33	2,67	3,00
Chaotic	3	2,5	2	3	3	3,5	1,5	1	2	2,39
ALL GROUPS AVERAGE	**3,81**	**3,63**	**3,69**	**3,69**	**3,44**	**3,75**	**3,06**	**1,94**	**3**	3,33



Graphic 3 – Leadership and teamwork external assessment, per leadership style

Differential between perception of leadership and its external assessment

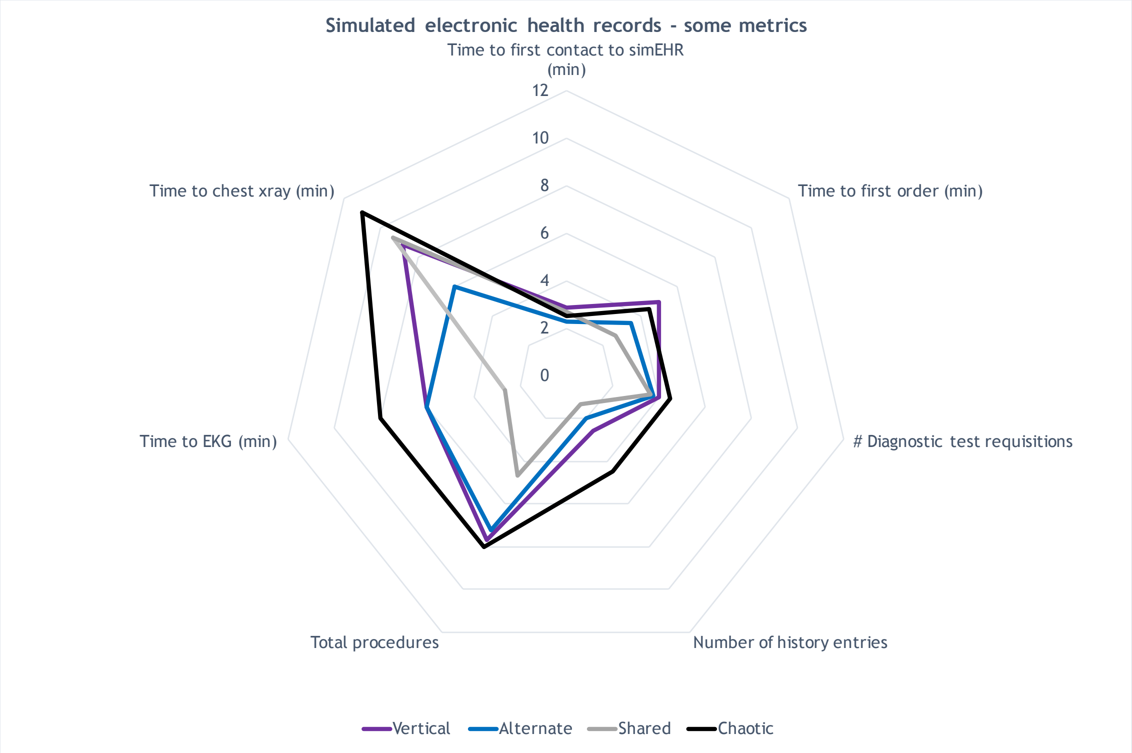
There is a higher differential between self and external assessment in chaotic groups. For the others, the average rates are similar.

Table 13 – Differential between external and self-assessment.

	Self-assessment global average	External assessment global average	Difference
Direct	3,57	3,54	0,04
Alternate	3,37	3,03	0,33
Shared	3,33	3	0,33
Chaotic	3,64	2,47	1,17

4.2. Efficiency and performance

Metrics concerning times and system interactions



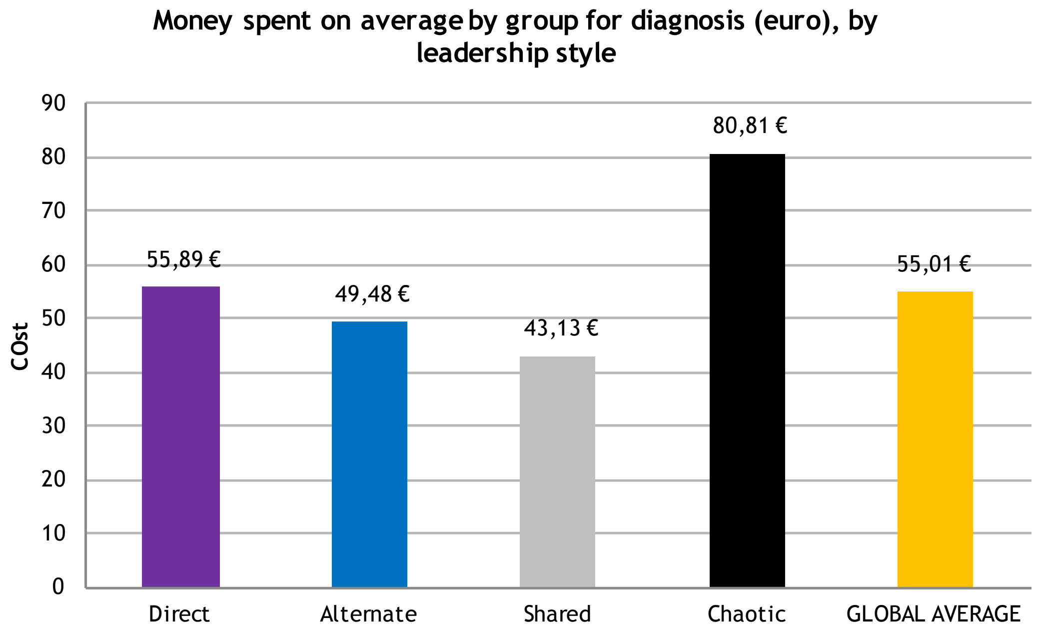
Graphic 4 – Metrics related with time and interactions with the system

How teamwork and leadership relates with system interactions

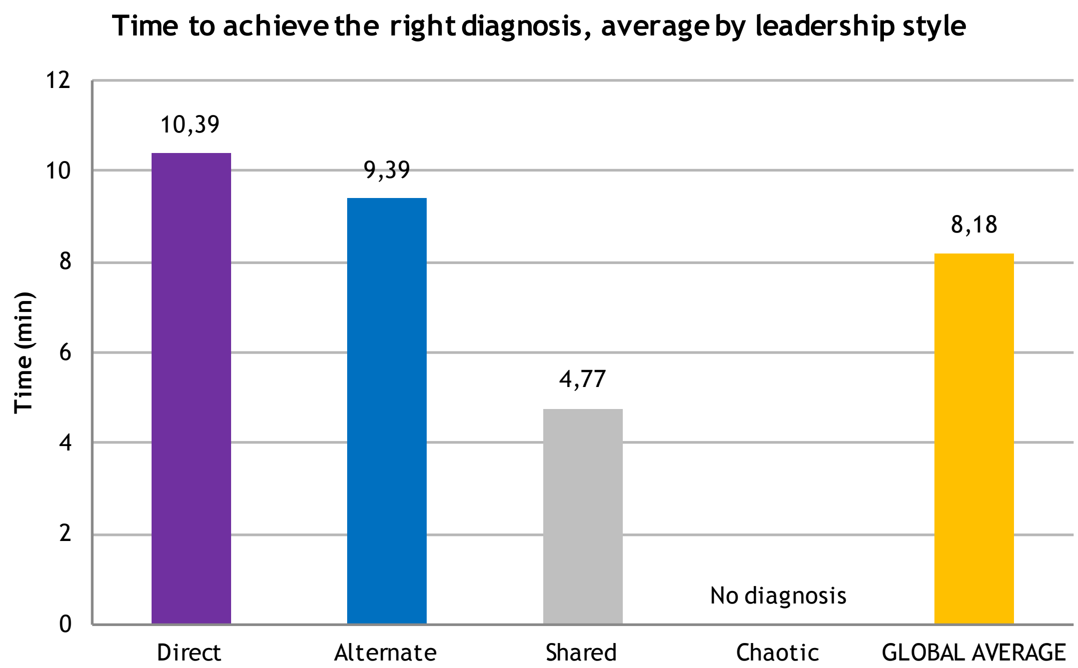
Groups with alternate and vertical style of leadership asked first for EKG and Chest X-ray, considered important for our scenario. Groups classified as chaotic took longer to ask for those diagnostic tests. They made more text entries, related with the clinical history and performed more clinical procedures.

Diagnostic tests: costs and time

In terms of costs with diagnostic tests, groups categorized by the observer as chaotic spent more money than the other leadership styles. Also, they do not identify the right diagnosis during the simulation. Direct leadership groups appear to take more time than the other two to achieve the right diagnosis.



Graphic 5a – Costs in diagnostic tests, per leadership style



Graphic 6b – Time to right diagnosis (pneumothorax), per leadership style

When cost is spread over time, a measure of team efficiency (table 13), we see no difference between values for Direct and Alternate, and an almost double result for shared.

Table 14 – Cost/time, per leadership style.

	Direct	Alternate	Shared	Chaotic	Average
Cost (€)	55,89 €	49,48 €	43,13 €	80,81 €	55,01 €
Time (min)	10,39	9,39	4,77	N/A	
Cost/time	5,38 €	5,27 €	9,04 €	N/A	

5. Discussion

In this observational study, using a mixed methodology, the sample was composed of individuals with ages between 21 and 36 years. 35% of the participants have had a previous higher education experience, before entering medical school. Some of these participants were also previously employed for more than six months, which theoretically has been associated with a better capacity to organize and manage teamwork. This confirms the researched literature, by stating differences in terms of leadership for experienced and non-experienced workers. As in Portugal we have a college entry system, there is a lack of studies considering this particular situation, as many countries have different access systems to medical school.

It was possible to establish an association with time-related efficiency metrics with the leadership style present in each group. Direct and alternate leadership groups have better external assessments on leadership and teamwork skills. Groups categorized as chaotic did not reach a final diagnosis neither could solve the diagnosis nor treat the simulated patient at their responsibility. Chaotic groups also spent significantly more money. The higher number of system interactions, sometimes repeated, can support the attribution of this categories to the groups. These number of interactions, in a real situation, could have brought higher costs to the team when compared with other teams categorized with the remaining three leadership styles. Concerning time to diagnosis, despite chaotic groups (who don't reach the right diagnosis), direct leadership groups take longer to get to it. This might be explained by direct leaders who might not share that much information, not enabling their team members to cooperate in the clinical reasoning process. We could not find enough literature on this topic, so further studies might be needed.

With a restricted sample it is difficult to conclude which is the most efficient leadership style to this scenario. Nevertheless, we can infer that the alternate leadership style resulted in better clinical indicators, e.g., time to diagnosis, time to key diagnostic tests.

Regarding questionnaires answered immediately after the simulation, they promote a self-critic and reflection about the performance of the team. This is also verified during the debriefing, which was not the focus of the present study, but was observed by the author. It is curious to note that chaotic groups have an optimistic perception of their performance, probably due to a higher degree of active, though unorganized, participation. This might be explained by less self-awareness/critical thinking capabilities in those groups (Laura, P. et al, 2006). Special focus should be given to these groups in order to promote self-awareness on leadership skills.

Medical students at UBI are more familiar with simulation than probably any other medical students in Portugal. This is important and evident during the study's simulations, particularly noted in easeful and smooth procedure execution. Simulations, as live experiments, are an essential component of hands-on learning.

Depending on the organization of each group concerning task allocation, led by the participants before the initiation of the simulation, the interaction with the system differed. It is important to note that while there were groups highly dependent on the system, who would wait for the diagnostic tests results and sometimes forgetting the patient's physical examination or monitoring, opposite groups were also observed.

Any of these cases reveals a lack of teaching in this area, confirming the reviewed literature (Schenarts, P. et al). This demands for leadership teaching.

It is also important to note that different action triggers (family, patient clinical status change, phone interactions, etc.) were important leadership shifters. Even though some groups made task distributions before starting the scenario, those factors were important "ice breakers", in terms of leadership patterns. Simulation is particularly important for this objective, so that teams can better understand their leadership individual profiles.

However, in some cases, the perception of high fidelity in a simulation scenario is only supported by the physical presence of a patient simulator, leaving the scenario too focused on the "robot", while context and non-technical skills are disregarded.

The used systems (simulated EHR, video and questionnaires) gather an immense amount of data that, when integrated, reveal an outstanding quantity of useful information. However, there is a lack of evidence on how can a researcher dig in this complex field (Schenarts, P. et al). Further studies will be needed to assess and validate this kind of frameworks.

In summary and addressing the four research questions:

- Teamwork and leadership does not occur spontaneously. It has to be learned and rehearsed and simulation is an excellent tool for teaching, rehearsing and analyzing team performance. Introduced action triggers offer realistic training opportunities that were linked to observable team processes and performance metrics. Debriefing sessions followed each simulation. Discussion on team dynamics and interactions at team level occurred, allowing team members to have a comprehensive view on team process issues and to develop a shared mental model of the team's performance, as suggested by Murphy, M et. al. Teams were able to identify which processes worked and decide on strategies to improve future performance. The same author suggests that training was associated with timelier decision making as teams recognize critical events earlier and initiated interventions in a time critical manner. In fact, students claim to have learned by these simulation sessions.

- It is possible to introduce an information system to manage this process. In fact, after this experience it's difficult to imagine how such amount of useful data could be obtained without the used systems. Information systems give us the ability to improve quality of data and capacity to work on that data, extracting useful metrics and analysis.
- Despite the small sample of this study, differences were found regarding self-assessment and external assessment for chaotic groups, who rated themselves higher than the external observer did. Previously published results by Rudy et al. (2001) and Bryan et al. (2005) demonstrated that student leaders consistently scored themselves lower than their peers on many aspects of leadership, including altruism, compassion, integrity, accountability, commitment to excellence, and self-reflection. Several reasons may account for this discrepancy in self- and peer evaluation of student leaders. Self-evaluation scores may be lower than peer scores because student leaders lack self-confidence in their own leadership abilities. Medical students find it difficult to be objective when evaluating their own performance (Laura, P. et al, 2006). Despite these considerations, the simple fact of promoting this individual critical reflection adds enormous value, when combined to a post simulation debriefing for all team members.
- This study showed the urgent necessity for the creation of systems that analyze training activities, around the clock and with powerful analytics engines. Such could allow prospective and retrospective studies based on clinical outcomes on a medium and long term. In the next section, supported by all the apprenticeship provided by this research, it is outlined some requirements, objectives and design considerations on how an integrated information system to manage this process could be.

5.1. Future work: a model for an integrated Leadership Learning System (LLS)?

It was outlined the main objectives, requirements and design of a possible integrated information system to manage leadership learning (LLS). The keys for success are integration and power analytics engines. It was envisioned a system that could integrate all the steps of a simulation-based curriculum (pre-simulation, during simulation, immediate post-simulation, debrief and follow-up), in a longitudinal way. This way, data analysis can be facilitated promoting retrospective evaluation and prospective identification and planning for needed training, according to each trainee profile, along the time.

Objectives

Table 15 – LLS objectives.

OBJECTIVES		
Train/Assessment	**Test**	**Compare**
Leadership	Processes	Personal development
Teamwork	Systems' usability	Team performance
Clinical competencies		Faculties and Hospitals
Clinical reasoning		Clinical Scenarios
Compliance with processes		User experiences
Conflict management		Processes
		Costs

Requirements

Table 16 – LLS requirements.

REQUIREMENTS		
Simulation	**Interaction**	**Data Collection**
Learners authentication system	Patient configuration	Data entries with timestamp
EHR with interoperability	Case pre-sets	Diagnostic tests and therapeutics with timestamp
Multidisciplinary integration (nurses, assistants, etc.)	Library of diagnostic test results	Diagnostics coded with HL7
Diagnostic test requisition and visualization		Interactions with the system
Electronic prescription		Prescription pattern analysis
		Cost calculation
		Voice: - Number of different voices - Dominant voice
		Video: - Movement patterns (color stick in learners back) - Gestures and posture tracking

Design

Table 17 – LLS design

DESIGN				
Pre-simulation	**Simulation**	**Post-immediate**	**Post-simulation (Debrief)**	**Follow-up**
General information about previously acquired skills and competencies	Interaction	Dynamic surveys (related to group's performance)	Automated video analysis	Key learning messages sent to student as Learning alerts
	Clinical data entries		Integration with mannequin sensors	Repetition
	Prescription		Differential audio recording	
	Diagnostic test viewer			

6. Conclusions

Healthcare costs have increased with the higher availability of expensive treatments and the expansion of life expectancy, which means patient-centered care is the rule with patient safety, teamwork and efficiency gaining even more relevance.

Higher degrees of professionalism and multi professionalism development within healthcare workers are key to this challenge. Such skills are more important now as different health professionals are involved in management roles. Biomedical simulation is a growing reality in under and post-graduate contexts. With a high degree of realism, supported by high-fidelity simulators executing a variety of behaviors and actions, simulation is gathering an increasing number of followers.

In Covilhã, it was developed a Leadership and Health management curricula for medical students, mandatory in the fifth year, and pioneer in Portugal. After ten year of experience, it was decided to climb the Millers pyramid of competencies, introducing simulation as an instrument of teaching. The attention was focused on the development of non-technical skills and teamwork. In order to augment the fidelity and realism of the sessions, as well as optimizing its maximum potential, a simulated EHR was developed.

Regarding the review conducted, leadership and management can use simulation as a way to add value to the theoretical bases of teaching. It creates a more real context than what can be though in lectures, with special importance to the debriefing as a way to reveal and tackle failures and discover improvement opportunities. Although, in a global context, simulation is most of the times used with the primary objective of technical competencies acquisition and clinical reasoning, it is demonstrated by the present study that it is also possible to use these same sessions placing the primary objective on leadership and teamwork skills training.

It was also proved to be possible the introduction of an information system, not only to support this process, as to add value as a factor augmenting fidelity and easing interaction between trainees and educators. Serving as an electronic health records tool, useful as a means of communication and perpetuating information, but placing the focus on learning with the measurement of several indicators, we can prove the role this system can have in learning.

In fact, this is the approach, in some way, reported in the literature, although most of the times a real system is used with a black database. In this case, important data is lost.

Using this system made it possible to collect self and external perceptions of leadership in our study groups. Differences were found regarding chaotic groups, who rated themselves higher than the other groups.

On the other hand, as explained in the discussion, the existence of a simulated software for electronic health records can be an important source for software training, user experience testing and, of course, development of clinical reasoning competencies.

In Portugal, being one of the OCDE countries with most evolved healthcare IT solutions, having a pioneering public healthcare system, we are in the perfect ecosystem to introduce solutions such as the one reported in this study, early in the curriculum of medical students and even extend it two post-graduate context. In this way, professionals can become more efficient and important conclusions may be gather to influence future developments.

7. References

Abbas, M. R., Quince, T. a, Wood, D. F., & Benson, J. a. (2011). Attitudes of medical students to medical leadership and management: a systematic review to inform curriculum development. *BMC Medical Education*, *11*(1), 93. http://doi.org/10.1186/1472-6920-11-93

Bloice, M. D., Simonic, K.-M., & Holzinger, A. (2014). Casebook: a virtual patient iPad application for teaching decision-making through the use of electronic health records. *BMC Medical Informatics and Decision Making*, *14*(1), 66. http://doi.org/10.1186/1472-6947-14-66

Briggs, A., Raja, A. S., Joyce, M. F., Yule, S. J., Jiang, W., Lipsitz, S. R., & Havens, J. M. (2015). The role of nontechnical skills in simulated trauma resuscitation. *Journal of Surgical Education*, *72*(4), 732–739. http://doi.org/10.1016/j.jsurg.2015.01.020

Chen, Y., Carroll, R. J., Hinz, E. R. M., Shah, A., Eyler, A. E., Denny, J. C., & Xu, H. (2013). Applying active learning to high-throughput phenotyping algorithms for electronic health records data. *Journal of the American Medical Informatics Association*, *20*(e2), 1–7. http://doi.org/10.1136/amiajnl-2013-001945

Cheng, A., Eppich, W., Grant, V., Sherbino, J., Zendejas, B., & Cook, D. A. (2014). Debriefing for technology-enhanced simulation: A systematic review and meta-analysis. *Medical Education*, *48*(7), 657–666. http://doi.org/10.1111/medu.12432

Cortegiani, A., Russotto, V., Montalto, F., Iozzo, P., Palmeri, C., Raineri, S. M., & Giarratano, A. (2015). Effect of High-Fidelity Simulation on Medical Students' Knowledge about Advanced Life Support: A Randomized Study. *PloS One*, *10*(5), e0125685. http://doi.org/10.1371/journal.pone.0125685

Erdogan, A., Dong, Y., Chen, X., Schmickl, C., Sevilla Berrios, R. A., Garcia Arguello, L. Y., … O'Horo, J. C. (2016). Development and validation of clinical performance assessment in simulated medical emergencies: an observational study. *BMC Emergency Medicine*, *16*(1), 4. http://doi.org/10.1186/s12873-015-0066-x

Farri, O., Pieckiewicz, D. S., Rahman, A. S., Adam, T. J., Pakhomov, S. V, & Melton, G. B. (2012). A qualitative analysis of EHR clinical document synthesis by clinicians. *AMIA ... Annual Symposium Proceedings / AMIA Symposium. AMIA Symposium*, *2012*(11), 1211–20. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3540510&tool=pmcentrez&rendertype=abstract

Fernandez Castelao, E., Boos, M., Ringer, C., Eich, C., & Russo, S. G. (2015). Effect of CRM team leader training on team performance and leadership behavior in simulated cardiac arrest scenarios: a prospective, randomized, controlled study. *BMC Medical Education, 15*(1), 116. http://doi.org/10.1186/s12909-015-0389-z

Fletcher, G., Flin, R., McGeorge, M., Glavin, R., Maran, N., & Patey, R. (2003). Anaesthetists' non-technical skills (ANTS): Evaluation of a behavioural marker system. *British Journal of Anaesthesia*, *90*(5), 580–588. http://doi.org/10.1093/bja/aeg112

Hu, Y.-Y., Parker, S. H., Lipsitz, S. R., Arriaga, A. F., Peyre, S. E., Corso, K. A., … Greenberg, C. C. (2015). Surgeons' Leadership Styles and Team Behavior in the Operating Room. *Journal of the American College of Surgeons*, *222*(1), 41–51. http://doi.org/10.1016/j.jamcollsurg.2015.09.013

Huettermann, H., Doering, S., & Boerner, S. (2014). Leadership and team identification: Exploring the followers' perspective. *Leadership Quarterly*, *25*(3), 413–432. http://doi.org/10.1016/j.leaqua.2013.10.010

Humbert, A. J., Besinger, B., & Miech, E. J. (2011). Assessing clinical reasoning skills in scenarios of uncertainty: Convergent validity for a script concordance test in an emergency medicine clerkship and residency. *Academic Emergency Medicine*, *18*(6), 627–634. http://doi.org/10.1111/j.1553-2712.2011.01084.x

Jansen, D. A. (2014). Student perceptions of electronic health record use in simulation. *Journal of Nursing Education and Practice*, *4*(9), 163–172. http://doi.org/10.5430/jnep.v4n9p163

Jarodzka, H., Balslev, T., Holmqvist, K., Nyström, M., Scheiter, K., Gerjets, P., & Eika, B. (2012). Conveying clinical reasoning based on visual observation via eye-movement modelling examples. *Instructional Science*, *40*(5), 813–827. http://doi.org/10.1007/s11251-012-9218-5

Jorge, M. L. da S. G., Coelho, I. C. M., Paraizo, M. M., & Paciornik, E. F. (2014). Leadership, management and teamwork learning through an extra-curricular project for medical students: descriptive study. *Sao Paulo Medical Journal = Revista Paulista de Medicina*, *132*(5), 303–306. http://doi.org/10.1590/1516-3180.2014.1325685

Kiesewetter, J., Schmidt-Huber, M., Netzel, J., Krohn, A. C., Angstwurm, M., & Fischer, M. R. (2013). Training of leadership skills in medical education. *GMS Zeitschrift Für Medizinische Ausbildung*, *30*(4), Doc49. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3839077&tool=pmcentrez&rendertype=abstract

Kolbe, M., Grande, B., & Spahn, D. R. (2015). Briefing and debriefing during simulation-based training and beyond: Content, structure, attitude and setting. *Best Practice and Research: Clinical Anaesthesiology*, *29*(1), 87–96. http://doi.org/10.1016/j.bpa.2015.01.002

Kononowicz, A. A., Zary, N., Edelbring, S., Corral, J., & Hege, I. (2015). Virtual patients--what are we talking about? A framework to classify the meanings of the term in healthcare education. *BMC Medical Education*, *15*(1), 11. http://doi.org/10.1186/s12909-015-0296-3

Kuhn, T. M., Barr, M. S., & Gardner, L. A. (2010). EHR- Based Quality Measurement and Reporting: Critical for Meaningful Use and Health Care Improvement. *The Medical Informatics Subcommittee of the American College of Physicians (ACP)*, (February 2010). Retrieved from http://www.acponline.org/acp_policy/policies/ehr_quality_measurement_critical_meaning_hc_2010.pdf

Landman, A. B., Redden, L., Neri, P., Poole, S., Horsky, J., Raja, A. S., … Poon, E. G. (2014). Using a medical simulation center as an electronic health record usability laboratory. *Journal of the American Medical Informatics Association*, *21*(3), 558–563. http://doi.org/10.1136/amiajnl-2013-002233

Levett-Jones, T., & Lapkin, S. (2013). A systematic review of the effectiveness of simulation debriefing in health professional education. *Nurse Education Today*, *34*(6), e58–e63. http://doi.org/10.1016/j.nedt.2013.09.020

Lewis, R., Strachan, A., & Smith, M. M. (2012). Is high fidelity simulation the most effective method for the development of non-technical skills in nursing? A review of the current evidence. *The Open Nursing Journal*, *6*, 82–9. http://doi.org/10.2174/1874434601206010082

March, C. a., Steiger, D., Scholl, G., Mohan, V., Hersh, W. R., & Gold, J. A. (2013). Use of simulation to assess electronic health record safety in the intensive care unit: a pilot study. *BMJ Open*, *3*(4), e002549–e002549. http://doi.org/10.1136/bmjopen-2013-002549

March, C. a., Steiger, D., Scholl, G., Mohan, V., Hersh, W. R., & Gold, J. A. (2013). Use of simulation to assess electronic health record safety in the intensive care unit: a pilot study. *BMJ Open*, *3*(4), e002549–e002549. http://doi.org/10.1136/bmjopen-2013-002549

Martins, H. M. G. (2010). Why management and leadership education for internists? *European Journal of Internal Medicine*, *21*(5), 374–376. http://doi.org/10.1016/j.ejim.2010.04.014

Masters, K. (2015). The e-patient and medical students. *Medical Teacher*, (December), 1–3. http://doi.org/10.3109/0142159X.2015.1112896

Matson, Christine, Stephens, Mark, Steiner, Beat, Kozakowski, S. M. (2014). Electonic Health Records: How will Students Learn if they can't Practice? *Annals of Family Medicine*, *12*(6), 582–583. http://doi.org/10.1370/afm.1716.ELECTRONIC

Milano, C. E., Hardman, J. A., Plesiu, A., Rdesinski, R. E., & Biagioli, F. E. (2014). Simulated electronic health record (Sim-EHR) curriculum: teaching EHR skills and use of the EHR for disease management and prevention. *Academic Medicine : Journal of the Association of American Medical Colleges*, *89*(3), 399–403. http://doi.org/10.1097/ACM.0000000000000149

Morgan, P. J., Kurrek, M. M., Bertram, S., LeBlanc, V., & Przybyszewski, T. (2011). Nontechnical Skills Assessment After Simulation-Based Continuing Medical Education. *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare*, *6*(5), 255–259. http://doi.org/10.1097/SIH.0b013e31821dfd05

Motola, I., Devine, L. A., Chung, H. S., Sullivan, J. E., & Issenberg, S. B. (2013). Simulation in healthcare education: A best evidence practical guide. AMEE Guide No. 82. *Medical Teacher*, *35*(10), e1511–e1530. http://doi.org/10.3109/0142159X.2013.818632

Murphy, M., Curtis, K., & McCloughen, A. (2015). What is the impact of multidisciplinary team simulation training on team performance and efficiency of patient care? An integrative review. *Australasian Emergency Nursing Journal*. http://doi.org/10.1016/j.aenj.2015.10.001

O'Meara, P., Munro, G., Williams, B., Cooper, S., Bogossian, F., Ross, L., … McClounan, M. (2015). Developing situation awareness amongst nursing and paramedicine students utilizing eye tracking technology and video debriefing techniques: A proof of concept paper. *International Emergency Nursing*, *23*(2), 94–99. http://doi.org/10.1016/j.ienj.2014.11.001

Passmore, G. G. (2014). Concept Mapping as a Meaningful Learning Tool to Promote Conceptual Understanding and Clinical Reasoning for Resident and Distance Learning Students Concept Mapping as a Meaningful Learning Tool to Promote Conceptual Understanding and Clinical Reasoning f.

Pell, G., Homer, M., & Fuller, R. (2015). Investigating disparity between global grades and checklist scores in OSCEs. *Medical Teacher*, *37*(December), 1106–1113. http://doi.org/10.3109/0142159X.2015.1009425

Quince, T., Abbas, M., Murugesu, S., Crawley, F., Hyde, S., Wood, D., & Benson, J. (2014). Leadership and management in the undergraduate medical curriculum: a qualitative study of students' attitudes and opinions at one UK medical school. *BMJ Open*, *4*(6), e005353. http://doi.org/10.1136/bmjopen-2014-005353

Radovich, P., Palaganas, J., Kiemeney, J., Strother, B., Bruneau, B., & Hamilton, L. (2011). Enhancing leadership orientation through simulation. *Critical Care Nurse*, *31*(5), 58–63. http://doi.org/10.4037/ccn2011463

Sadideen, H., Weldon, S. M., Saadeddin, M., Loon, M., & Kneebone, R. (2016). A Video Analysis of Intra- and Interprofessional Leadership Behaviors Within "the Burns Suite": Identifying Key Leadership Models. *Journal of Surgical Education*, *73*(1), 31–39. http://doi.org/10.1016/j.jsurg.2015.09.011

Saitwal, H., Feng, X., Walji, M., Patel, V., & Zhang, J. (2010). Assessing performance of an Electronic Health Record (EHR) using Cognitive Task Analysis. *International Journal of Medical Informatics*, *79*(7), 501–506. http://doi.org/10.1016/j.ijmedinf.2010.04.001

Schenarts, P. J., & Schenarts, K. D. (2012). Educational impact of the electronic medical record. *Journal of Surgical Education*, *69*(1), 105–112. http://doi.org/10.1016/j.jsurg.2011.10.008

Schmutz, J., Eppich, W. J., Hoffmann, F., Heimberg, E., & Manser, T. (2014). Five steps to develop checklists for evaluating clinical performance: An integrative approach. *Academic Medicine*, *89*(7), 996–1005. http://doi.org/10.1097/ACM.0000000000000289

Seidel, B. M., Campbell, S., & Bell, E. (2015). Evidence in clinical reasoning: a computational linguistics analysis of 789,712 medical case summaries 1983-2012. *BMC Medical Informatics and Decision Making*, *15*(1), 19. http://doi.org/10.1186/s12911-015-0136-8

Sigalet, E., Donnon, T., Cheng, A., Cooke, S., Robinson, T., Bissett, W., & Grant, V. (2013). Development of a Team Performance Scale to Assess Undergraduate Health Professionals. *Academic Medicine*, *88*(7), 989–996. http://doi.org/10.1097/ACM.0b013e318294fd45

Sigalet, E., Donnon, T., & Grant, V. (2012). Undergraduate students' perceptions of and attitudes toward a simulation-based interprofessional curriculum: the KidSIM ATTITUDES questionnaire. *Simulation in Healthcare : Journal of the Society for Simulation in Healthcare*, *7*(6), 353–8. http://doi.org/10.1097/SIH.0b013e318264499e

Skog, A., Peyre, S. E., Pozner, C. N., Thorndike, M., Hicks, G., & Dellaripa, P. F. (2012). Assessing Physician Leadership Styles: Application of the Situational Leadership Model to Transitions in Patient Acuity. *Teaching and Learning in Medicine*, *24*(3), 225–230. http://doi.org/10.1080/10401334.2012.692269

Sousa, M., & Van Dierendonck, D. (2016). Introducing a short measure of shared servant leadership impacting team performance through team behavioral integration. *Frontiers in Psychology*, *6*(January), 1–12. http://doi.org/10.3389/fpsyg.2015.02002

Steinemann, S., Kurosawa, G., Wei, A., Ho, N., Lim, E., Suares, G., … Berg, B. (2016). Role confusion and self-assessment in interprofessional trauma teams. *The American Journal of Surgery*, *211*(2), 482–488. http://doi.org/10.1016/j.amjsurg.2015.11.001

Stephen J. Zaccaroa,*, A. L. R., & Michelle A. Marksb. (2001). Team leadership. *The Leadership Quarterly*, *12*, 451–483. http://doi.org/10.1016/S1048-9843(01)00093-5

Stephenson, L. S., Gorsuch, A., Hersh, W. R., Mohan, V., & Gold, J. a. (2014). Participation in EHR based simulation improves recognition of patient safety issues. *BMC Medical Education*, *14*(1), 224. http://doi.org/10.1186/1472-6920-14-224

Szulewski, A., & Howes, D. (2014). Combining first-person video and gaze-tracking in medical simulation: A technical feasibility study. *The Scientific World Journal*, *2014*. http://doi.org/10.1155/2014/975752

Thinking, C., & Reasoning, C. (2010). Critical thinking and clinical reasoning. *Pearsonhighered.com*. Retrieved from http://www.pearsonhighered.com/berman-10e-info/assets/pdf/CH10.pdf

Weiner, J. P., Fowles, J. B., & Chan, K. S. (2012). New paradigms for measuring clinical performance using electronic health records. *International Journal of Quality Health Care*, *24*(3), 200–205. http://doi.org/10.1093/intqhc/mzs011

Weller, J., Henderson, R., Webster, C. S., Shulruf, B., Torrie, J., Davies, E., … Merry, A. F. (2014). Building the Evidence on Simulation Validity. *Anesthesiology*, *120*(January 2014), 142–148.

Westli, H. K., Johnsen, B. H., Eid, J., Rasten, I., & Brattebø, G. (2010). Teamwork skills, shared mental models, and performance in simulated trauma teams: an independent group design. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *18*(1), 47. http://doi.org/10.1186/1757-7241-18-47

Wills, M. J., El-Gayar, O. F., & Deokar, A. V. (2012). Evaluating the Impact of Electronic Health Records on Clinical Reasoning Performance. *2012 45th Hawaii International Conference on System Sciences*, 2830–2839. http://doi.org/10.1109/HICSS.2012.254

Wu, B., Wang, M., Johnson, J. M., & Grotzer, T. A. (2014). Improving the learning of clinical reasoning through computer-based cognitive representation. *Medical Education Online*, *19*(1), 1–8. http://doi.org/10.3402/meo.v19.25940

Yu, T.-C., & Zhou, H. (2015). Benefits of applying a proxy eligibility period when using electronic health records for outcomes research: a simulation study. *BMC Research Notes*, *8*, 229. http://doi.org/10.1186/s13104-015-1217-6

Annexes

ANNEX 1 - Post-simulation questionnaire

Dados gerais

Idade *

A sua resposta

Género *

○ Feminino

○ Masculino

Percurso académico

Frequentou algum outro curso previamente à frequência do curso de Medicina da FCS-UBI? *

○ Sim

○ Não

Exerceu alguma profissão/trabalho remunerado por mais de 6 meses?

○ Sim

○ Não

Aplicando os conhecimentos adquiridos no bloco de liderança e gestão em saúde, responda às questões seguintes.

Liderança e gestão de equipa

Para cada uma das questões seguintes, seleccione a opção que mais se aplica à sua percepção sobre a performance da sua equipa no cenário de simulação.

Sentiu que existia uma liderança evidente da equipa em todos momentos *

	1	2	3	4	5	
Discordo plenamente	○	○	○	○	○	Concordo plenamente

Sentiu que houve uma distribuição clara das tarefas *

	1	2	3	4	5	
Discordo plenamente	○	○	○	○	○	Concordo plenamente

Considera que todos participaram activamente para a resolução do caso *

	1	2	3	4	5	
Discordo plenamente	○	○	○	○	○	Concordo plenamente

Considera ter existido comunicação efectiva entre os membros da equipa *

	1	2	3	4	5	
Discordo plenamente	○	○	○	○	○	Concordo plenamente

Os membros da equipa solicitaram opiniões aos colegas *

	1	2	3	4	5	
Discordo plenamente	○	○	○	○	○	Concordo plenamente

ANNEX 2 - Two month after simulation questionnaire

Liderança e gestão em Saúde — Pós-simulação

Questionário curto destinado aos estudantes do quinto ano de medicina da FCS-UBI que realizaram uma simulação avançada no contexto do bloco de Liderança e Gestão em Saúde.
O questionário é anónimo e destina-se a ser incluído na dissertação de mestrado de Duarte Sequeira, estudante nº 26643.

*Obrigatório

Sente que a simulação foi útil para a sua aprendizagem no âmbito de Liderança e Gestão em Saúde? *

- ○ Sim
- ○ Não

Estaria interessado em poder ter acesso à gravação de vídeo/áudio da simulação em que participou, bem como de respetiva análise? *

- ○ Sim
- ○ Não

Estaria interessado em repetir a experiência de forma mais regular? *

- ○ Sim
- ○ Não

SUBMETER